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Guidelines for EPA Review of Environmental Impact Statements on Projects Involving Impoundments

Curran Associates, Inc, Northampton, Mass

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With the exception of highly controversial projects, the bulk of the EPA impoundment project reviews has been and will continue to be conducted at the regional level. To adequately perform these reviews, each regional EIS Coordinator (and attendant review personnel) must have the best available information on both the technical and procedural aspects of EIS reviews on these projects. The report will help to fill the need for this information and will be used as the draft version of the EPA guidelines for the review of EIS's on projects involving impoundments.

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GUIDELINES FOR EPA REVIEW OF ENVIRONMENTAL IMPACT STATEMENTS ON PROJECTS INVOLVING IMPOUNDMENTS

FINAL REPORT

Contract No. 68-01-2924

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PREFACE

With the exception of those highly controversial projects, the bulk of the EPA impoundment project reviews has been and will continue to be conducted at the regional level. To adequately perform these reviews, each regional EIS Coordinator (and attendant review personnel) must have the best available information on both the technical and procedural aspects of EIS reviews on these projects. The report will help to fill the need for this information and will be used as the draft version of the EPA guidelines for the review of EIS's on projects involving impoundments.

Preparation of the guidelines document was closely coordinated with the Office of Federal Activities. Sincere thanks are extended to Mr. William Dickerson, Project Officer, for his cooperation, guidance and suggestions throughout the study, and to others who reviewed and offered constructive criticism on various drafts of the report. Within Curran Associates, special appreciation is due Mr. Jeffrey R. Folts, Project Manager for the Study, Mr. Alan P. Asikainen and Mr. Robert C. MacKenzie for their technical contributions, and Ms. Frances C. Morrier for typing of the final report.

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CHAPTER I

INTRODUCTION

Development of water resources continues at a high level in response to needs for water supply, flood control, irrigation, power generation, navigation, and other purposes. At the same time pressures for conservation or preservation are increasing because of concerns for ecological, historical, aesthetic, and recreational values as well as a heightened awareness that natural resources are rapidly being lost to development of all kinds. This conflict between development and preservation is particularly evident in the case of impoundment projects, since the major commitments of a freely flowing stream and riparian lands to permanent or periodic inundation are essentially unavoidable and irreversible as long as the project remains in place.

The issue of resource commitments in terms of land, natural stream and alteration of riverine ecology for an impoundment is therefore fundamental to an assessment of environmental impacts. The initial surge of EIS's prepared during the first two or three years following the passage of the National Environmental Policy Act of 1969 focused to a large extent on impoundments for which construction was already underway or designs were completed. This resulted in a somewhat perfunctory analysis of viable project alternatives, as construction of an impoundment was a foregone conclusion. Both because the backlog of EIS's for these projects has been reduced and court decisions have better interpreted the requirements of NEPA, a much more complete and substantive analysis of alternatives, both impoundment and nonimpoundment, for meeting water resource objectives should be expected. Often the basic question of whether or not a certain stream should be impounded sparks the most controversy and cannot be adequately answered using traditional methods of analyzing benefits and costs. Intangible costs relating to maintenance of natural environmental values take on greater significance as the supply of the affected resources declines, and yet monetary values for land acquisition, recreation-days lost, and other factors do not adequately reflect these costs. Therefore, the weighting of impacts that involve long-term resource commitments needs to be examined very carefully in the context of environmental goals and objectives. Virtually all of the larger streams in the United States have been studied and identified as potential impoundment sites. Even though many of these may never be developed, it is nevertheless imperative that the planning and environmental assessment be carried out so as to ensure that proposed projects, if constructed, represent environmentally acceptable uses of the land and water resources to be committed.

EPA's involvement in the impoundment process stems from the mandates of the National Environmental Policy Act (NEPA) of 1969 and the Clean Air Act Amendments of 1970. Section 102(2)C of the NEPA stipulates that

> Prior to making any detailed statement, the responsible Federal official shall consult with and obtain the comments of any federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved. Copies of such statement and the comments and views of the appropriate federal, state, and local agencies, which are authorized to develop and enforce environmental standards, shall be made available to the President, the Council on Environmental Quality and to the public as provided by section 552 of title 5. United States Code, and shall accompany the proposal through the existing agency review processes;...

In view of the legal jurisdiction of and special expertise within EPA, this section obligates federal agencies to obtain comments from EPA wherever an action related to air or water quality, noise abatement, solid waste disposal, generally applicable environmental radiation criteria and standards, or other provisions of the authority of EPA are involved. In addition, section 309 of the Clean Air Act Amendments of 1970 gives EPA the explicit legal mandate to comment in writing on the environmental impact of any matter relating to EPA's duties and responsibilities.[1] Section 309 provides

> (a) The Administrator [of EPA] shall review and comment in writing on the environmental impact of any matter relating to duties and

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[1] A listing of relevant legislation, Executive orders, and Office of Management and Budget circulars and bulletins may be found in "Basic Documents Concerning Federal Programs to Control Environmental Pollution from Federal Government Activities," prepared by the Office of Federal Activities, U.S. EPA, February 1975.

> responsibilities granted pursuant to this Act or other provisions of the authority of the Administrator, contained in any (1) legislation proposed by any federal department or agency, (2) newly authorized federal projects for construction and any major federal agency action (other than a project for construction) to which Section 102(2)(C) of Public Law 91-190 applies, and (3) proposed regulations published by any department or agency of the federal government. Such written comment shall be made public at the conclusion of any such review.
>
> (b) In the event the Administrator determines that any such legislation, action, or regulation is unsatisfactory from the standpoint of public health or welfare or environmental quality, he shall publish his determination and the matter shall be referred to the Council on Environmental Quality.

To implement this responsibility, the EPA manual Review of Federal Actions Affecting the Environment[2] (hereafter referred to as "Transmittal 2") has established detailed policies, responsibilities, and administrative procedures for the Agency's review of federal actions impacting the environment. This transmittal provides that, where an environmental impact statement (EIS) has been sent to EPA for comment, EPA's comments on the EIS shall also constitute its comments for purposes of section 309. Because Transmittal 2 does not provide guidance for the technical review of EIS's, the Office of Federal Activities, in conjunction with the EPA program and regional offices, is in the process of preparing detailed review guidelines for several major project categories.

As one of the documents in that series, this document provides the detailed procedural and technical guidance for the EPA review of impoundment projects. At this stage of development, the approach of the guideline is one of unifying the various review and technical documents currently in use by placing them in the context of the impoundment project review process. The figure following illustrates the organization of the document. Note that several review "check lists" are provided. It is suggested that these check lists be utilized to insure that all relevant areas have been reviewed (using Chapter IV as necessary to determine the applicability of each check list item).

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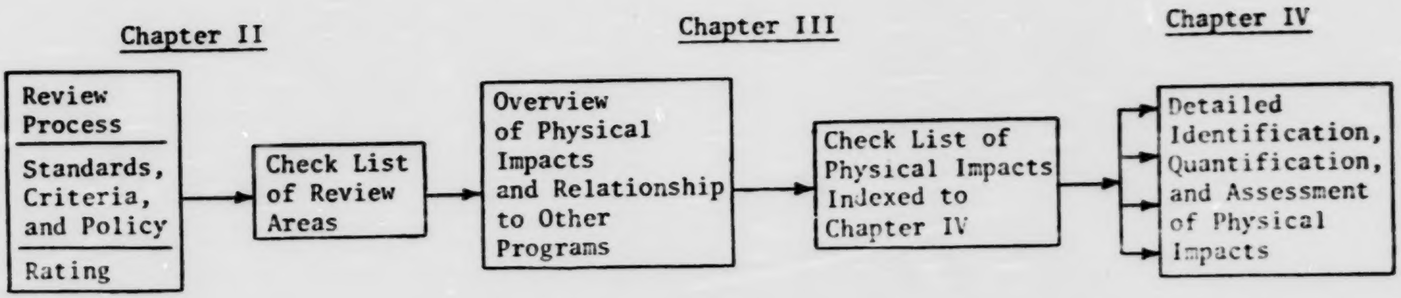
[2] Transmittal No. 2, March 1, 1975.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CHAPTER II

EPA INVOLVEMENT IN IMPOUNDMENT PROJECTS

Transmittal 2 provides the general policy and procedures guidance applicable to the EPA involvement in all projects. This chapter excerpts and expands those sections relevant to the technical review of impoundment projects. For information concerning the EPA management of the review process the reader should consult Transmittal 2. The opportunities for and the limits of the EPA's involvement in impoundment projects are described in the following subsections in terms of the review process, the environmental standards, criteria, and policy, and the project/EIS rating schemes.

A. The Review Process

As described in Transmittal 2, it is EPA policy that the review process include pre-EIS activities, draft EIS reviews, pre-final EIS liaison, final EIS reviews, and post-final EIS follow-up. It should be kept in mind that the payoff of this process should be an "effective" project review. Generally, reviews can be considered effective when they: (1) are expressed in constructive language that is pertinent to the particular action; (2) add EPA support for projects having a beneficial impact on the environment; (3) point out specific environmental problems that a proposed action might cause and, if possible, specify the environmental requirements that must be met and the means by which a more environmentally satisfactory project can be attained; (4) are part of a continued working relationship with the originating agency to improve project planning and design processes; (5) focus sharply on environmentally unsatisfactory actions, and provide substance for follow-up work with the agency to deter the project until environmentally satisfactory actions can be worked out.

The successful implementation of each of the review process phases is, in part, dependent on a thorough understanding of the process used by the various agencies in the formulation of new projects. The EIS coordinator (as manager of the regional review process) is encouraged to establish an on-going contact with the appropriate field offices of the involved agencies and to understand their planning process and associated outputs that might be useful in determining an early environmental assessment of developing projects. The Appendix contains brief descriptions of the planning processes of the Corps of Engineers, Soil Conservation Service, Bureau of Reclamation, Tennessee Valley Authority, Federal Power Commission, Water Resources Council and River Basin Commissions, and the Fish and Wildlife Service. The remaining sections in this chapter utilize these process descriptions.

A.1 Pre-EIS Activity

"Pre-EIS Activity" is a generic term for anticipating future impoundment projects. Within the limits of their resources, the EIS coordinators should maintain general pre-draft EIS liaison with their counterparts in other agencies. In addition to providing background information on future EIS's (and thus improving the EIS review), such liaison provides opportunities for the coordinator to determine if there are projects for which EIS's should be prepared and to provide assistance, as requested, to the EIS preparers.*

In conducting the pre-draft liaison, priority should be given to projects under construction which have been halted to allow preparation of an EIS. Pre-draft EIS liaison may consist of any of the following:

- --Review of an applicant's environmental report or pre-draft EIS prior to receiving an EIS;
- --Review of negative declarations prepared by federal agencies;
- --Attendance at federal agency meetings where the action is described and the EPA official has the opportunity to assess the importance of the action and to provide any input necessary to the sponsoring agency to identify EPA areas that need to be considered in the EIS;
- --Substantive discussions with federal agency officials responsible for for a proposed action;
- --Providing to federal agency officials background materials for use in developing an EIS;
- --Review of former EPA (pre-draft EIS) program files on a proposed action, e.g. review of a watershed work plan or water resource project report and the assessment of the extent to which the project or EPA's views may have changed since any past review was made; or

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*If either of these situations occur, the procedures given in the Review Manual should be followed.

--Site visits, especially where a project presents a significant potential for environmental disruption of a valuable natural area or is likely to be an environmentally unsatisfactory action.

In the early stages of planning SCS will write to EPA's regional offices to seek consultation on matters within EPA's area of responsibility and special expertise. (See section 650.10(a)(6) of the SCS NEPA regulations.) It is the responsibility of the EIS coordinator to ensure that the region is responsive to the SCS request for technical assistance as the planning process is initiated.

A.2 Review of Draft EIS's

EPA's comments on environmental impact statements (EIS's) should reflect the total environmental responsibilities of EPA, especially in those cases where the basic nature of the EIS indicates a need for a coordinated multiprogram response (see section II.B). EPA comments should strive to stimulate appropriate consideration of primary and secondary environmental effects by other federal agencies in their decision-making process. Comments should stress fundamental environmental issues and should be of a constructive nature, suggesting, where possible, not only what should be improved, but also discussing alternatives warranting consideration. The review of the draft EIS should address both the environmental impact of the action and the adequacy of the information presented in the draft EIS (see section II.C). Comments on the adequacy of the document are to assist the originating agency in developing a comprehensive impact analysis in the final EIS.

As an aid in checking the points covered in the review, a review "check list" is given below. Since no single check list can be applied to all situations, the reviewer is cautioned to utilize the technical review information in Chapters III and IV to determine which, and to what extent each of the check list items apply to the specific project under review.

A.2.a Project Description

(1) Review the project setting

(2) Review project functions in terms of the impacts of each separable project purpose.

(3) Review the condition of the watershed, including:

- --Soil and geology characteristics.
- --Livestock areas and agricultural lands.
- --Towns, industries and waste treatment facilities.
- --Discharge points and nonpoint sources of waste discharge.
- --Logging areas, mining or other land management and resource utilization activities.
- --Existing or potential modifications to the natural hydrology of the water body; existing impoundments.
- --Characteristics of land to be inundated and extent of clearing to be performed.

(4) Flow Regime

- --Review the hydrologic characteristics of the water body--flow ranges, etc.
- --Flooding characteristics and flood recurrence intervals.

(5) Water Quality

- --Review the quality of inflowing water, recognizing that quality is a function of condition of upstream watershed. All major sources of pollutants (municipal and industrial, feedlots, agricultural areas) should be identified.
- --Review present water quality parameters under conditions of varying flow, specifically low flow.
- --Review the present sediment load carried by the water. Determine which areas within the project watershed exhibit erosion potential or may contribute turbidity or sediment due to construction and operation of the project. Expected project life should also be estimated.

(6) Review project design, utilizing pictures and charts of major project features (including areas subject to drawdown).

(7) Review the project operation.

- --Schedule of releases for each project function.
- --Water level fluctuations.
- --Levels and areas of conservation and flood control pools.
- --Locations of water intakes and/or outlets.
- --Other pertinent information as needed.

A.2.b Environmental Impacts

It is important to recognize the complexity of the changes that can occur in water quality due to impoundment and artificial management of a river. These changes can be broadly classed as:

(1) Changes which might occur in the water due to the presence of the project, including water quality changes due to impoundment such as DO depletion in bottom layers, seasonal temperature stratifications, effect on sediment transport, warming trends, potential eutrophication.

(2) Changes which might occur in water quality due to project operation. For instance, operation of a reservoir for flood control can prolong the release of turbid water later in the year than normal and can appreciably alter temperature regime of the stream for a distance below the dam. Similarly, elimination of high velocity flood flows can disrupt the flushing action of the river and can lead to increased sediment accumulation and resultant effects on aquatic life. Levels of outlets will be important in the regulation of water quality and temperature of released waters. This may affect downstream uses as well as downstream ecology.

A.2. c Alternatives

Review all practicable alternatives, including:

(1) The alternative of "no project."

(2) Scope of project.

(3) Location.

(4) Preservation of river. Review the potential for inclusion of the river in the National Wild and Scenic Rivers System or a similar state system to preserve the natural values of the river.

(5) Alternative methods of accomplishing each proposed project function. For instance, in the case of flood control, show that adequate consideration has been given to nonstructural alternatives such as flood plain management or zoning, flood-proofing, etc.

A.2.d Relationship of Short-Term Uses vs. Long-Term Productivity

(1) Effects project will have on natural value of free-flowing rivers, which must be considered diminishing resources themselves.

(2) Potential long-term decreases in environmental productivity due to artificial control of basin hydrology for short-term economic gain.

(3) Review of EO 11296; evaluation of flood hazard in locating federally owned or financed buildings, roads and other facilities and in disposing of federal lands and properties.

A.2.e Irreversible and Irretrievable Commitment of Resources

(1) Effects of connecting a free-flowing river to an operated and artificially managed water body.

(2) Potential commitment of river's flood plain for surface water use and general development.

A.3 Pre-Final Impact Statement Consultation

Efforts should be maintained to follow up and work with agencies which have submitted draft EIS's rated categories ER, EU, or 3, so that they are improved at the final stage. At the request of the principal reviewer, appropriate EPA personnel meet with officials of the initiating agency to discuss EPA's comments, to provide additional information, and to recommend means to improve the proposed action and supporting EIS. Meetings conducted at the Headquarters level shall be coordinated by OFA. If an agency requests an EPA position on a proposed final EIS, the principal reviewer may acknowledge tentative concurrence or nonconcurrence with the agency's response to EPA's comments on the draft EIS. However, care should be taken to avoid written statements that can be taken as an EPA "endorsement" of an action or "objection" to an action on nonenvironmental grounds.

SCS has requested that EPA be available to provide an evaluation of its response to the EPA comments on draft EIS's not rated "LO." In order to comply with SCS's request for an EPA position on proposed final EIS's for drafts rated ER, EU, or 3, comments on these documents should be made within 30 days of receipt, if the EPA concerns have been adequately resolved in pre-final consultation. In addition, the reviewer should acknowledge EPA's tentative concurrence with SCS's response to the comments on the draft through a letter subsequent to the pre-final EIS consultation. Care should be taken to avoid written statements that can be taken as an EPA "endorsement" of a project or "objection" to a project on nonenvironmental grounds. If comments cannot be resolved with SCS during pre-final consultation, the normal final EIS review procedure should apply.

Follow-up on EPA's comments on draft EIS's relating to permits under consideration for issuance pursuant to Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the FWPCAA of 1972 is expecially important because of the Administrator's responsibility under Section 404(c). Principal reviewers should assure that the final EIS contains sufficient information to provide a basis for the exercise of the Section 404(c) responsibility.

A.4 Final EIS Review

For each draft EIS which was rated category 2, 3, ER, or EU, the final EIS will be reviewed to determine whether the statement substantially resolves the problems surfaced by the draft EIS. The principal reviewer will consult and coordinate, as necessary, with other EPA offices (Headquarters and regional) who reviewed the draft EIS. In reviewing the final EIS, primary attention should be directed to substantive issues related to assessing the environmental impact of the proposed action.

However, the principal reviewer shall also review final EIS's where the Agency's draft EIS comments were rated 2 or 3 to ensure that the originating agency provides sufficient information for a comprehensive review of the final EIS. It is necessary that the review of the final EIS be effected in an expeditious manner to ensure that comments generated by EPA be issued to meet the 30-day deadline afforded before the initiating agency may take action on the proposed project.

A.5 Project Follow-Up

After completion of the reviews of an EIS, the principal reviewer is responsible for conducting post-EIS follow-up where EPA evaluates the proposed action as reflected in the final EIS to contain environmental reservations or to be environmentally unsatisfactory or the final EIS to be unresponsive. The principal reviewer should effect post-EIS liaison by preparing a plan of action and submitting such plan to OFA for Headquarters comment and coordination. The plan of action shall provide an outline of the follow-up activities the principal reviewer intends to initiate to monitor whether the originating agency undertakes actions which have been the subject of such EIS's in an environmentally protective and sound manner. In carrying out his post-EIS follow-up responsibilities, the principal reviewer shall ensure that he coordinates his activities with appropriate state and local environmental protection officials and other EPA officials (e.g. regional or state enforcement officials for NPDES permitting, regional enforcement officials for Section 404 enforcement, and regional air program officials for transportation control strategy compliance and state implementation plan requirements, etc.).

B. Standards, Criteria and Regulations

The basis for the EPA comments on the environmental impact of impoundment projects is quite broad; as stated in the Clean Air Act, Section 309(a), EPA comments on "...any matter relating to duties and responsibilities granted pursuant to this Act or other provisions of the authority of the Administrator..." and the NEPA, Sec. 102(2)(C) "...the responsible federal official shall consult with and obtain the comments of any federal agency which has jurisdiction by law or special expertise with respect to the environmental impact involved."

The above mandates have generally been interpreted to mean that the EPA comments should be related to the impact of projects on water quality, air quality, solid waste management, noise, radiation control and pesticide and other toxic substance use and control; thus comments related to land use, fish and wildlife, aesthetics, recreation, and other areas must be related to these areas of expertise. For example, it is proper to discuss residential or industrial development that an impoundment project may induce if it will aggravate an already serious air or water pollution problem.

If, however, an EPA reviewer has special insight on a project, such as that resulting from an on-site inspection or discussion with community leaders, it is also appropriate to make comments on matters falling outside of EPA's specific areas of jurisdiction. The EPA policy is that such comments are for information only and are not used to justify the assigned EPA rating. Furthermore such comments must include a statement to the effect that final determination on the matter is deferred to the federal agency with the appropriate jurisdiction.

The specific bases for the EPA assessment of environmental impacts consist of the standards, criteria, EPA policy decisions, and consistency requirements with other EPA program responsibilities as described below.

B.1 Standards

- --Water Quality: State adopted water quality standards consisting of water quality criteria and plans for the enforcement and implementation as referenced in 40 CFR Part 120.
- --Air Quality: National primary and secondary ambient air quality standards as specified in 40 CFR Part 50.

B.2 Criteria, Regulations and Policy

- --Criteria for Water Quality, Volume I (Proposed) U.S. EPA, October 1973.
- --Water Quality Information, Volume II (Proposed), U.S. EPA, October 1973.
- --Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, U.S. EPA, March 1974.
- --Regulation for the Disposal and Storage of Pesticides and Pesticide Containers, 40 CFR Part 165.
- --EPA Policy to Protect the Nation's Wetlands, Administrator's Decision No. 4.
- --Navigable Water, Procedures and Guidelines for Disposal of Dredged or Fill Material, 40 CFR Part 230.

- --Policy on Storage and Releases for Water Quality Control in Reservoirs Planned by Federal Agencies, 16 January 1973 (two enclosures) and amendment, 31 October 1973.
- --Implementation of Policy on Storage and Releases for Water Quality Control in Reservoirs Planned by Federal Agencies, 7 February 1973.

B.3 Consistency with Other EPA Programs

- --Areawide Waste Treatment Management Planning Areas ("208" plans), 40 CFR Part 126.
- --Water Quality Management Basin Plans ("303(e)" plans), 40 CFR Part 131.
- --National Pollutant Discharge Elimination System, 40 CFR Part 125.
- --State Air Implementation Plans, 40 CFR, Parts 50 and 51.

C. Project Rating

As detailed in Transmittal 2, the EPA rating scheme is different for draft EIS's, final EIS's and pre-Clean Air Act Amendments EIS's. At the draft stage, comments shall be designated by an environmental impact rating of LO (Lack of Objections), ER (Environmental Reservations), or EU (Environmentally Unsatisfactory) and an EIS adequacy rating of Category 1 (Adequate), Category 2 (Insufficient Information) or Category 3 (Inadequate). If a draft EIS is assigned a category 3, ordinarily no rating will be made on the environmental impact of the proposed project or action, since a basis does not generally exist on which to make such a determination. However, when there is a basis for assessing the environmental impact of a proposed action (e.g., independent documents or on-site surveys), such a rating may be established at the discretion of the principal reviewer after consultation with OFA.

At the final stage, no alpha-numeric designations are made since, in general, only the project impact is considered, not the completeness of the EIS. The project impact rating assignments for the final EIS consist of Lack of Objection, Environmental Reservations and Environmentally Unsatisfactory. In addition, a rating assignment of Unresponsive Final Impact Statement can be made if the final EIS has not responded to comments made by EPA on the draft EIS or due to an inadequately prepared final EIS. Such comments may also be offered if new environmental concerns have been brought to the EPA's attention since the review of the draft EIS and the originating agency does not adequately evaluate these factors in the final EIS.

In either type of review situation, the rationale for assigning a rating will remain the same. The general criteria for assigning the Environmental Reservation, Environmentally Unsatisfactory, or Category 3 ratings are given below. The reviewer should note, however, that these criteria are intended to be used as guidelines rather than strict rules. The decision regarding the impact of each project must incorporate all the mitigating factors for that particular project. The sensitivity of the impoundment environment to the changes imposed by the project, as well as the effectiveness of mitigating measures, must be taken into account.

C.1 General Criteria for Category "Environmental Reservations"

(1) Rare natural resources are directly or indirectly destroyed by the project, during operation or construction, where the natural resources are not protected by federal or state regulations;

(2) The project described in the statement is part of a series of proposed projects and the cumulative effect of the series will have detrimental effects while the project itself will not.

(3) The long-term effects of the proposed project are serious and have not been taken into account.

C.2 General Criteria for Category "Environmentally Unsatisfactory"

(1) Where it is highly probable that a violation of standards will occur (see Section II.B.1). There will be projects which as an initial step do not violate standards, but inherently create significant pollution problems in related areas. If there is a demonstrable connection between the initial project and future related developments which create the likelihood of the violation of standards, this may be a basis for the unsatisfactory determination.

(? Where there is a violation of an EPA policy declaration (see Section II.B.2).

(3) Where there are no applicable standards or where applicable standards will not be violated but there is potential for significant environmental degradation which could be mitigated by other feasible alternatives (not including the no project alternative).

(4) Where there are no applicable standards or where applicable standards will not be violated but there is potential for severe environmental degradation relating to EPA's areas of jurisdiction or expertise.

C.3 General Criteria for Category "Inadequate"

(1) The EIS contains insufficient information to permit a reasonable review of project features considered in the EIS, including failure to provide information to permit an evaluation of primary effects or significant secondary effects, which are covered by EPA's standards, regulations, or policies. Specifically the following areas must be described in detail:

--Water quality in the proposed impoundment (incoming water)

--Flow data to determine amount of land affected by drawdown.

--New flow regime and effects on downstream biota.

--Comparison of water quality to state drinking water standards and applicable EPA drinking water standards.

--Comparison of water quality to water standards and criteria for recreational use (if applicable)

--Cumulative effects.

(2) The EIS fails to consider adequately important project features which EPA believes have a significant impact on the environment. This situation is most likely to occur where an initiating agency is attempting to cover a broad class of actions with an EIS which may not be designed as an overview EIS. If certain project components are not covered and the agency's intent is not to prepare subsequent EIS's on these aspects, the category 3 rating should point out the features which will be required in subsequent EIS's and define the types of information which should be included in the subsequent EIS's. If subsequent EIS's will not be prepared, then designated information should be included in the existing EIS.

CHAPTER III

OVERVIEW OF ENVIRONMENTAL IMPACTS OF IMPOUNDMENT PROJECTS

In assessing the effects of an impoundment project both the "physical" impacts resulting from the project and the relationship of the project to other projects and related programs must be evaluated. Syntheses of the major considerations for both types of review are given below.

A. Physical Impacts of Impoundment Projects

In addition to the cumulative impacts of impoundment in terms of the loss of land and a section of freely flowing stream, incremental changes occurring within the impoundment watershed must also be dealt with. The water quality of influent streams will have a strong bearing on resultant water quality and ecological conditions in a reservoir and downstream. Impoundment water quality will be impacted, probably to a greater degree than the unimpounded stream would have been, because of a general reduction of assimilative capacity in the artificial lake. Alterations of water quality that take place in the reservoir will similarly be transferred to downstream reaches. The high probability that the quality of impounded water will be poorer than that of streams flowing into the impoundment has important implications for specific impounded water uses. Since public water supply is usually the most quality-sensitive use, any lowering of quality in the reservoir will detract from that use and may necessitate increased treatment costs for removal of iron, manganese, tastes and odors, algae, or other undesirable substances. These costs should be fully evaluated as a component of total costs of the project.

Downstream from an impoundment, water quality may be affected directly by releases of better or poorer quality water and indirectly by alteration of natural flows, water temperatures, and waste assimilative capacities. Stream conditions are not likely to remain static over the life of an impoundment, however, and impacts which may appear to be minor may become highly significant when viewed in conjunction with other incremental effects. An impoundment alone may alter the thermal regime of a stream only slightly. Discharges of treated wastewater and cooling water, increased urban runoff from paved areas, and removal of streamside vegetation may also have small effects individually on stream temperatures. Yet, the combined effects may jeopardize the maintenance of the natural stream ecosystem. The same analysis may apply to changes in flow regime, which arise not only from impoundments but also from downstream withdrawal uses of river water, diversion, and other losses.

Changes in water quantity and water quality downstream from a dam are certain to affect river ecology. Elimination or reduction of either cold or warm-water species of fish, invertebrates, and other fauna can be anticipated at impoundments that significantly change the thermal regime of the river. Flow regulation, alone or along with temperature and other changes, may interrupt fish migration and spawning. Stabilization of flows may provide conditions more favorable to some fish species, yet reduction of bank overflows will detrimentally affect the seasonal wetland vegetation characteristic of undeveloped river bottom lands and valley storage areas. Traditionally, modification of fish and wildlife resources, vegetation, and the ecology of areas affected by impoundments has been equated with losses or gains of hunting, fishing or other recreational opportunities in order to assign measures of economic importance to these alterations. This sort of analysis ignores many of the intangible values associated with preservation of remaining rivers in their natural states. For example, areas of unique ecological or geological value would not be adequately evaluated using this technique alone.

Many indirect ecological impacts are related quite simply to changes in land use and increased development pressures resulting from impoundment construction. Intensive recreational use of shoreline areas around a reservoir will adversely affect wildlife and wildlife habitat, as will the relocation of roads, railroads and other facilities above the maximum reservoir elevation. Residential or second home development along the shorefront and on adjacent hillsides also has detrimental impacts on terrestrial ecology. It is evident that describing wildlife losses and habitat reduction as simply inundation of a given area in the reservoir is incomplete. In the longer term, increased traffic and home development will exert additional pressures on wildlife in areas surrounding an impoundment. Impacts can similarly be traced to land use changes in downstream flood plains offered greater protection by an impoundment project and in areas of water use for water supply or irrigation.

Primary and secondary impacts on water quality, land use, and ecology incorporate the major concerns for most impoundment projects. It should be realized, however, that adequate assessment techniques do not exist for all impacts, even those which can be accurately identified and predicted. For instance, downstream ecology can sometimes be altered substantially by fairly small changes in flow regime, temperature, characteristics of the stream bed, and other factors while all parameters addressed in applicable water quality standards and criteria are being met. Moreover, such subtle shifts in ecology can rarely be evaluated in economic terms. These problems cannot be readily resolved within the existing framework of environmental criteria. Nevertheless, such impacts should be evaluated as fully as possible to perhaps indicate a need for more comprehensive environmental quality standards or further study of the impact area significance.

The environmental effects and feasibility of project alternatives should be described sufficiently in an EIS so that trade-offs among the alternatives are readily apparent. In the case of multiple-purpose projects, a combination of nonimpoundment alternatives would probably be required to meet various water resource development objectives. Groundwater development and direct withdrawal from a freely flowing stream, as well as water conservation and wastewater reuse, may be viable alternatives to impoundment for meeting water supply needs. There are a variety of structural and nonstructural approaches to flood control, as alternatives to a reservoir, including acquisition and removal of structures from flood hazard areas, flood plain land use regulations (zoning ordinances, subdivision regulations, building codes, etc.), floodproofing, flood insurance, channelization, and local protection projects. These and other alternatives should be reviewed carefully. The goal is to avoid premature rejection of alternatives that might have significantly less environmental impact than the main proposal.

Solid waste, noise and air quality impacts are of secondary importance at impoundment projects, except in special cases where effects may be significant due to site characteristics, location or other factors. These areas are within EPA's authority and responsibility, however, and review of an impoundment EIS should include an assessment of probable impacts whether or not they have been explicitly considered in the EIS.

Table III-1 lists those physical impacts described above and gives the locations in Chapter IV for detailed discussions of their identification, quantification, and assessment. Since this table is a comprehensive list of environmental impacts associated with impoundment projects in general, the reviewer must determine the applicability of each item to the specific project at hand (through the use of Chapter IV and other sources). By proceeding in this way, Table III-1 may be used as a check list to help insure a complete review.

B. Coordination with Water Quality Management Programs

The extent of EPA's involvement in pre-EIS water quality planning for a proposed impoundment may depend on its magnitude, complexity, or regional significance. Any proposed withdrawal uses of water, such as for irrigation or municipal and industrial supply, will ultimately lead to increased wastewater discharges at some location, and must be analyzed in the context of ongoing water quality management planning. Flood control may induce further development of "protected" flood plain areas or cause other changes in land use that may result in potentially increased stormwater runoff and sewering and sewage treatment requirements.

The basin planning program under Section 303(e) of the FWPCA Amendments of 1972 provides the overall framework for implementing applicable effluent limitations and water quality standards in individual river basins. These plans, which delineate pollution abatement strategies for a five- to ten-year period, may be affected by an impoundment project in several ways. Some of the factors relating to water quality planning which should be considered during the planning of a reservoir and/or during the EIS review are discussed below.

(1) Present and projected waste discharges within reservoir area - The basin plan will contain information on the location and characteristics of waste-

Table III-1: Key to Discussion of Impacts in Chapter IV

Topic	Page Reference in Chapter IV
Construction Phase Impacts	
Sediment pollution and stream siltation	15
Pesticides, petrochemicals, and other potential pollutants	16,17
Quantification of erosion and sediment generation	27
Relevant criteria for sediment pollution	55
Protection of water quality during construction	55,56
Erosion and sediment control techniques	57,58
Treatment of polluted water from construction site	59
Activity scheduling	63,64
Components of solid waste from construction operations	77
Disposal of chemicals and containers	80
Summary of solid waste impacts	83
Air pollution sources at construction sites	85
Noise generators at impoundment construction site	90
Typical construction noise levels	92
Rough estimation of noise impacts	93,95
Damaging effects of noise	94-96
Impacts in Impoundment	
Probable land use impacts	1,2
General methodology for evaluating land use changes and impacts	3,4
Loss of stream and bottom land	4,5
Relocation impacts	5
Recreational development	5
Secondary air pollution impacts (parking facilities)	89
Solid waste generation at recreational areas	81,82
Impact of land inundation on impoundment water quality	17
Organic decomposition and dissolved oxygen deficiency	18
Solution of iron and manganese	18
Loss of wildlife habitat	18,40
Assimilative capacity changes	
Primary determinants	19
Critical water quality conditions	19,20
Effects of stratification and density currents	20
Eutrophication and associated impacts	20,21
Consideration of evaporation	22,39
Shift from river to lake environment and reduction of species diversity	22,41
Sedimentation in impoundment	22
Modelling of impoundment water quality	28,29
Estimating significance of site conditions with respect to impoundment water quality	30,31
Potential for erosion in reservoir	32,33
Relationship of morphometry to potential eutrophication and weed problems	33-35

Table III-1: Key to Discussion of Impacts in Chapter IV (Continued)

Topic	Page Reference in Chapter IV
Impacts in Impoundment (Continued)	
Nutrient sources and loadings	35,37
Quantification of influent water quality	36
EPA responsibilities for point and nonpoint pollution sources	36
Probability of water quality problems in stratified reservoirs	37,38
Evaluation of reservoir fisheries	27,28
Summary of water quality parameters that may be affected by impoundment and relevant criteria	60
Thermal criteria for fisheries	61
Downstream and in areas of water use	
Influence of land acquisition policy on reservoir development	6,7
Induced development in region	8
Land use impacts due to increased flood protection	8
Land use impacts of irrigation impoundments	8,9
Evaluation of water pollution from irrigation	9,10
Policy concerning use of flood plains	10
Prevention of water quality degradation from irrigation projects	10-13
Impact of water quality changes on downstream biota	25,26
Impact of dam as barrier	26
Flow regime changes	
Quantification of hydrographic modification	43
Seasonal and diurnal flow variations	44
Minimum release requirements	44
Low-flow augmentation analysis	45
Effects on riparian vegetation	46
Flow requirements for salmon and other species	47,48
Temperature changes	
Important categories of fish species	49
Effects of outlet location and impoundment operation	50,51
Possible thermal effects on downstream species composition	52
Thermal criteria for fisheries	61
Effects on downstream uses	69-71
Alternatives for mitigating impoundment and downstream water quality impacts	
Reservoir clearing	63
Removal of soil and organic matter	64
Selective withdrawal	66-71
Turbine aeration	72,73
Howell-Bunger valves	73,74
Destratification and hypolimnetic aeration	74,75

water discharges. If a proposed impoundment is to be used for public water supply, water-contact recreation, or other purposes which require water of uniformly high quality, more stringent effluent limitations or even relocation of wastewater outfalls may be necessary. Nutrients, potentially toxic chemicals, organic matter, or other substances contained in treated wastewater discharges may be readily trapped and perhaps reach undesirable concentrations in the impounded water body, thereby reducing its value for intended uses.

(2) Alteration of hydrographic regime - A basin plan is to contain, for each water quality segment, an analysis of total maximum daily loads of those pollutants that violate applicable water quality standards, including provision for seasonal variation. The plan also establishes discharge load allocations or effluent limitations among significant discharges with an allowance for anticipated economic and demographic growth over at least five years. These determinations will generally be made through application of mathematical modeling techniques for specific flow conditions.

Many impoundments will be located on tributary streams where water pollution is not a problem. Nevertheless, their operation may cause major changes in the flow regime at downstream points where serious water quality problems do exist. Low flows may be augmented even if no storage has been allocated specifically for water quality control, and high flows during normally wet seasons may be severely curtailed as water is held for later release. Such changes may affect previously determined waste load allocations for downstream water quality segments or priorities for treatment plant construction.

EPA regulations[1] require that basin plans be revised every five years or more frequently where significant changes occur within the basin (as brought about, perhaps, by impoundment construction). The affected state should be consulted regarding the possible impacts of regulated flow patterns on its basin water quality management program. As a matter of policy concerning flow regulation by an impoundment project, EPA considers any flow regulation practices that result in lower than natural low flows to be in violation of the antidegradation clause of the water quality standards. On the other hand, any dependable upward revision of low flows which is expected from the operation of a proposed reservoir may affect interpretation of water quality standards and planning for individual treatment works. (Both water quality standards and design of treatment plants are based on a specific, often statistically derived low flow value that may not be representative of the post-impoundment flow conditions.) These issues should ideally be resolved by the state water pollution control agency, with the assistance of EPA, in the planning phase of an impoundment before the EIS is prepared and circulated.

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[1] Preparation of Water Quality Management Basin Plans, 40 CFR Part 131.

(3) Alteration of preimpoundment water quality - An impoundment may have both beneficial and adverse effects on downstream water quality, depending on the project purposes and features, existing water quality and other factors discussed in more depth in Chapter IV. Improvement of water quality may be directly related to increased streamflow and waste assimilative capacity or to the settling and retention characteristics of the reservoir pool. Because basin planning, areawide waste treatment management planning, and the discharge permit program are strongly oriented to the analysis and regulation of specific pollutants, predicted changes caused by impoundment may need to be considered. For example, an impoundment may substantially reduce suspended solids, turbidity, or coliform bacteria. If any of these parameters violate water quality standards or cause water quality problems in and downstream from a proposed reservoir area, then there may be cause for revising effluent limitations or other restrictions on these pollutants to allow for the "treatment" capacity of the impoundment. Any degradation of preimpoundment water quality, such as reduction of dissolved oxygen in the discharge, is unacceptable. Remedial measures should be evaluated during project planning and EIS review just as would be done for any other discharge which adversely affects water quality (see Section IV.B.3 for descriptions of several alternatives).

(4) Alteration of Water and Related Land Use - The direct and indirect changes in land use induced by a reservoir may have far-reaching effects on water quality, whether or not these changes can be accurately forecast. In some cases, implications for future land use may be readily apparent. For instance, the location and amount of land to be brought into agricultural production by use of impoundment-supplied irrigation water should be fairly

well defined. Likewise, storage allocated for municipal or industrial water supply may aid in supporting future development within or near those municipalities receiving the additional supply. Other growth may occur in the vicinity of the reservoir itself, due to enhanced recreational attractiveness, or in downstream flood plains if control storage is included.

Although development of particular areas would often be expected regardless of whether an impoundment were constructed, the project may nevertheless stimulate such growth earlier than would otherwise have occurred. Coordination of impoundment planning and basin water quality planning is necessary so that potentially accelerated development, especially in water-limited regions, is properly evaluated. Revision of growth projections in basin, land use and other plans may be required. As a consequence, allowances for wastewater volume increases may no longer be representative of expected conditions. EPA, in overseeing state water quality management programs should ensure that any such changes in relevant planning factors are properly considered and incorporated as necessary into the basin plan.

(5) Evaluation of Water Quality Control Storage - Section 102(b) of the Federal Water Pollution Control Act (FWPCA) Amendments of 1972 gives EPA full responsibility for determining the need for, the value of, and the impact of storage for water quality control at federally planned impoundments and impoundments licensed by the Federal Power Commission. EPA has issued a policy statement and guidelines to regional offices for implementing the requirements of Section 102(b). Pertinent EPA memoranda that are important for review of impoundment EIS's and for pre-EIS studies of water quality control storage are:

--"Policy on Storage and Releases for Water Quality Control in Reservoirs Planned by Federal Agencies" (16 January 1973) and two enclosures:

(a) "Guidelines of the Environmental Protection Agency Regarding Storage and Releases for Water Quality Control in Reservoirs Planned by Federal Agencies."
(b) Appendix, "Assessment of Adequate Treatment for Implementation of EPA Flow Regulation Policy."

--"Implementation of Policy on Storage and Releases for Water Quality Control in Reservoirs Planned by Federal Agencies" (7 February 1973)

--"Policy on Storage and Releases for Water Quality Control in Reservoirs," amendment to the first memorandum listed above (31 October 1973).

Policy and guidance contained in these documents apply both to requests for water quality storage studies and to the review of reports and EIS's involving federal proposals for reservoir storage allocated for water quality purposes. In studies leading to a recommendation for water quality control storage, all the environmental consequences of the action should be considered, so that EPA will be in a position to comment favorably on the water quality storage aspect when the draft EIS is circulated. This procedure thus obviates the need for an additional, detailed review of proposed storage for water quality control at the draft EIS stage.

It should be noted that releases from multiple-purpose projects for navigation, recreation, fish and wildlife conservation, or other nonwithdrawal uses may provide incidental water quality improvement benefits. EPA should evaluate flow regulation specifically for these purposes in terms of its effect on water quality. The impoundment planning agency, however, is responsible for actual determination of needs and values of storage allocated to purposes other than water quality control.

Generally, EPA expects that few recommendations for water quality storage will result from implementation of Section 102(b) and related EPA policy, due to the stringent water quality goals and waste treatment requirements that have been set forth in the 1972 Act Amendments. Such storage may be recommended (1) only after application of the best available pollution control technology economically achievable; and (2) only where the storage, in conjunction with adequate waste treatment, is demonstrated to be the best alternative for achieving water quality standards and goals.

CHAPTER IV

IDENTIFICATION AND ASSESSMENT OF PROJECT IMPACTS

A. Review of Land Use Impacts

Land use impacts related to construction and operation of an impoundment may not be limited just to the immediate project area. Therefore, it is critical that the scope of the EIS is broad enough to cover significant secondary land use effects which may be experienced downstream or in other locations. The primary focus of the review should be on the environmental impacts of land use changes expected following impoundment construction and on the significance of the affected natural resources.

A.1 Sources of Impacts

The impacts of an impoundment on land use may be associated with three different zones within the project's area of influence: (1) the reservoir area itself, (2) the immediate vicinity of the impoundment, including surrounding communities, and (3) the region that benefits from the project's functions and purposes. Identification and quantification of impacts become increasingly difficult in areas indirectly affected by, but geographically removed from the project site. Guidance for impact assessment, therefore, becomes less definitive and precise when dealing with impoundment-induced impacts on land use. Often-encountered land use impacts within an impoundment's area of influence are included in the following sections.

A.1.a In Impoundment

Impoundment construction necessitates acquisition and removal from existing uses of a certain amount of land area and natural stream. A number of environmental and socioeconomic impacts, both primary and secondary, may be associated with land conversion for a reservoir:

--Loss of freely flowing stream and associated recreational opportunities;
--alteration of aesthetic values;
--displacement of families;

--increase in employment during construction;
--loss of agricultural land and farm revenues;
--loss of forest land and timber production;
--loss of wetlands;
--increase in lake-related recreational opportunities;
--loss of archaeological resources; and
--loss of historic sites.

A.1.b In Vicinity of Impoundment

Land use changes and related impacts in the area surrounding an impoundment depend largely on the characteristics and purposes of the project. The following are examples of impacts that may occur at many types of impoundments:

--Relocation of transportation networks and utilities;
--change in property values;
--development of concessions and recreational service facilities;
--development of second homes;
--change in recreational use below dam;
--increase in traffic, noise and air pollution; and
--increase in waste disposal problems.

A.1.c In Impoundment Area of Influence

Possibly the greatest long-term land use impacts of an impoundment will be felt in those areas that receive project "outputs" such as flood control, water supply, irrigation, or recreation benefits. Impacts on land use may also occur in less well defined areas in the region, but it is difficult if not impossible to isolate the contributing influence of an impoundment from general economic and social stimuli for development. Concentrating, therefore, on areas principally affected by an impoundment, important land use changes and impacts may include:

--Further development of downstream flood plains;

- --concentration of growth and consequently pollution sources in urban or other areas receiving water supply;
- --loss of natural vegetative cover on newly irrigated lands;
- --impacts on existing agricultural producers and markets;
- --increase in wastewater discharges; and
- --pollution problems from irrigation drainage and runoff.

The above enumeration of land use impacts is far from complete; nevertheless, major environmental quality problems and impacts may accompany the general changes mentioned in any of the three sections used to separate an impoundment's different areas of influence. More detailed outlines of socioeconomic, land use and related ecological considerations can be found in publications by Hagan and Roberts[1] and Warner _et al_.[2]

A.2 Review of Impact Quantification

In viewing the long-term commitment of land for an impoundment, existing and potential future uses and values of the inundated area must be put into sufficiently broad perspective so that the magnitude and significance of the action can be estimated. Many natural resource and ecological values cannot presently be described fully in economic terms. For these values a reasonably accurate determination of regional significance or uniqueness is especially important. With respect to each category of land or stream use in a proposed impoundment area, then, an adequate description of impacts should address, and quantify as appropriate, at least the following:

(1) What is the magnitude of the resource involved (e.g. miles of stream, acres of agricultural bottom land)?

(2) What is the supply of similar resources in the vicinity of the project, the watershed and the region?

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[1] Hagan, R. M., and E. B. Roberts, "Ecological Impacts of Water Projects in California," Journal of the Irrigation and Drainage Division, ASCE, Vol. 98, No. IR1 (March 1972), pp. 25-48.

[2] Warner, M. L., _et al_., An Assessment Methodology for the Environmental Impact of Water Resource Projects, prepared for U.S. EPA, Office of Research and Development, Washington, D.C., July 1974 (EPA-600/5-74-016), pp. 151-174.

(3) What is the quality of the resource relative to similar resources in the region (fertile bottom land versus marginal agriculture nearby, good stream fishery, highly utilized waterfowl breeding area, etc.)?

(4) Does the resource have special significance because of uniqueness (historic or archaeological values, white water canoeing, spectacular scenic beauty, rare or endangered flora and fauna, etc.)?

(5) Can the resource commitment be mitigated or avoided by utilizing a different site, change in proposed pool elevation, or nonimpoundment development alternative?

Since land commitment for an impoundment is essentially permanent, the aspects of regional supply and quality of the particular resource should be projected into the future to a certain extent to complete the analysis. Considerations pertinent to quantification of various land use impacts are discussed below.

Loss of Stream. Nationally and regionally, natural, unimpounded rivers are diminishing resources. In few areas does the supply meet the demand, if not because of damming then because of water quality degradation or other factors that detract from the usefulness of streams for recreation and other purposes. A continuing decrease in the supply of natural streams also enhances the values of those remaining.

The loss of "x" miles of freely flowing stream must, therefore, be related to the availability both of other such streams in the region and of attendant values such as stream fishing for trout or other species, white water canoeing, or unique natural beauty. Because of the long-term commitment of a stream resource, it is not sufficient to quantify the environmental impact in terms of a loss of so many visitor-days per year. Rather, numerous intangible impacts and costs should also be expressed, at least through comparison with similar resources in the region. Important points to look for in the EIS to aid this assessment are:

--Description of other existing and authorized or proposed impoundments in the basin or region. If the impoundment constitutes only one of several projects in a comprehensive water resources development program, cumulative losses of natural streams may be critically important.

--Discussion of alternatives. The alternatives of "no-build," construction of a smaller project, a dry-bed reservoir, lower pool elevation, or location at a different site might avoid or reduce stream losses.

Loss of Agricultural and Forest Land. The best agricultural land in an area is often preempted for an impoundment site. Yet, it is probable that the need for this land will steadily increase while at the same time marginal lands are being brought into production and more fertile areas lost to various types of development. There is no way to mitigate the loss of highly productive river bottom land that is committed to reservoir use. The local impact of reduced agricultural productivity can be measured and assessed by relating the amount of farm land and the value of crops affected by an impoundment to similar parameters of the agricultural economy in surrounding areas. Regionally, the impact of changes in agricultural land use due to impoundment construction may be minor and, in any event, is usually difficult to quantify. However, these impacts may be cumulative.

The same comparisons for forest and timber land, pasture, natural wetlands and other land resources within the impoundment area aid in determining their importance near the project site.

Relocation Impacts. Relocation of residences, commercial establishments, transportation facilities, and even entire small communities is evaluated in terms of economic costs. Land use impacts may, however, extend into areas adjacent to a proposed impoundment, both directly as a result of the need for certain relocations and indirectly from the alteration of local resources. Construction or reconstruction of access roads, highways, railroads, transmission lines and other corridor-type utilities is commonly required at impoundment sites. Topography along the perimeter of a reservoir often presents more difficult conditions for construction than that of the lower valley. Consequently, adverse aesthetic and environmental impacts may accompany relocation of such facilities; these are best addressed in rigid construction specifications for the project.

Recreational Development Impacts. Development of extensive recreational facilities at an impoundment project can be expected to result in secondary environmental impacts. It is important that the number, type and location of proposed facilities, as well as projected initial and future recreational use, be specified in the EIS. Generally, intensively used recreation areas, such as campgrounds, picnic areas and swimming beaches experience greater environmental degradation than do hiking trails, nature study areas and other sites receiving less heavy use. Localized traffic congestion, degradation of air quality near parking lots, soil compaction, loss of vegetation, and potential water quality problems may occur and should be addressed in the EIS. Anticipated visitation on peak summer weekends should also be quantified.

Provision for recreational facilities in the project plan may stimulate development of supporting enterprises such as sporting goods stores, boat rentals, concessions, and other businesses. Such development may occur near the lake shore or in peripheral areas made accessible by pre-existing or relocated roads. Also, construction of cottages or summer homes overlooking or along the shoreline of the reservoir may take place, particularly if the impoundment does offer significant recreational opportunities.

The same factors of supply and quality discussed previously also pertain to water-based and shoreline recreational development at an impoundment. Some of the comments on the draft EIS for TVA's proposed Tellico Project, for instance, brought up the point that 19 other major impoundments with a total surface area of over 80,000 ha (200,000 acres) were located within an 80-kilometer (50-mile) radius of the Tellico site.[3] It was indicated that these impoundments could meet the demand for water-oriented recreation and, furthermore, that the reservoir fisheries were underutilized. These and similar issues should be appropriately discussed and quantitative data presented in the EIS in order that impacts can be fully assessed.

The land use changes in the vicinity of an impoundment may be influenced substantially by the amount of public land acquired at the periphery of the project. Federal acquisition in fee or easement allows close control over shorefront development and access to the reservoir. Land to be purchased by the government should be delineated on a reservoir map, along with the limits of the normal water surface. It is fairly common practice among federal impoundment-construction agencies to purchase lands within a taking line at a certain elevation, perhaps several feet above the spillway crest elevation, and to obtain flowage easements for areas that will only occasionally be inundated. Fee ownership of the reservoir perimeter may preclude development of private, shore-front homes and easements may specify compatible land uses such as agriculture or pasturage.

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[3] Tennessee Valley Authority, Final Environmental Statement, Tellico Project, Volume I, 10 February 1972, p. I-4-23.

Hillside overlooks and privately owned shoreline areas may be desirable locations for second homes or recreational enterprises. However, subsurface sewage disposal systems that typically are used to serve this type of development constitute a potential source of nutrients and other pollutants to the impoundment. The normal increase in human activity around an impoundment due to recreational use, relocation of roads, new access points, and second home development will also have an adverse impact on wildlife habitat in the area that, for the most part, cannot be avoided.

Regional Land Use. Provision of storage for flood control or irrigation may induce alteration of land use patterns in downstream flood plains and in areas of water use. These can usually be clearly identified, but the actual magnitude and importance of induced effects may be very difficult to estimate.

Because of EPA's broad responsibilities for water and air quality management programs, it is important that impoundment-related changes in land use be identified and assessed as to their impacts on these programs and on overall environmental quality. Projections of economic or demographic growth with and without an impoundment are very difficult to make, particularly since water availability is usually a necessary but not sufficient condition for growth.

Given time and resource constraints for review of an impoundment EIS, the data, projections, and descriptive information contained in the statement may furnish a base from which to assess the effects of induced land use changes.

Stimulation of further development in areas with existing, severe water or air quality problems, for example, may aggravate environmental degradation or complicate attainment of applicable quality standards.

Effects of Flood Control. For flood control, a variety of information is necessary for quantifying land use impacts, including:

(1) location and description of downstream damage centers, both agricultural and urban;

(2) the degree of flood protection afforded by the project;

(3) local or state flood plain regulations in effect;

(4) an indication of whether damage centers have qualified for federal flood insurance, and the extent to which landowners are utilizing the program;

(5) general economic, demographic and land use trends in flood-prone areas; and

(6) amount of undeveloped but readily developable area within the flood-prone area and flood hazard zone.

Development of areas subject to flooding is often encouraged by construction of an upstream storage reservoir, even when substantial flood risks still exist. Industries are especially apt to locate near the river because of the availability of process water. The desirability of growth in the downstream flood plain, particularly in urban areas, should be evaluated in light of water and air quality problems. If severe problems do exist, stimulation of additional development may lead to further deterioration of environmental quality. Possible industrial expansion warrants careful analysis, since introduction of new waste discharges might complicate the state basin planning program and hinder attainment of water quality goals.

Effects of Irrigation. The impacts of developing agricultural land must be analyzed for impoundments supplying irrigation water. The following factors are important for quantification of environmental impacts in the area of irrigation water use:

(1) amount, location and drainage characteristics of land to be brought into production;

(2) existing vegetative cover and uses of land to be brought into production;

(3) types of crops expected;

(4) irrigation methods to be employed;

(5) amount of return flow, discharge locations and general water quality of receiving stream; and

(6) probable salinity and other pollutant increases and method of treatment, if any.

The existing character of land to be irrigated must be described in relation to its ecological values and physical features. Ecological impacts will probably be less, for example, in conversion of already cultivated land or pasture to more intensive irrigated agriculture than in altering natural grasslands or flood plain areas. Similarly, physical features of the area, including soil type and salinity, location of the water table, and topography will affect long-term agricultural use and potential water quality in nearby streams.

Water pollution from irrigated lands is generally associated with overland runoff and drainage water. Pollutants accompanying runoff include sediments, nutrients, pesticides and decaying vegetation, while irrigation return flows in the form of drainage water may also contain high concentrations of dissolved solids composed primarily of ions of sodium, calcium, magnesium, potassium, boron, chloride, bicarbonate, sulfate, and nitrate.[4] Present technology is inadequate for predicting the quality of irrigation return flow; consequently, the problems resulting from irrigation development are usually confronted after-the-fact.[5] Because such estimates are more likely to be qualitative than quantitative in the EIS, only general observations on water quality changes may be possible. In any case, dissolved solids, nutrients, and perhaps pesticides and suspended solids concentrations would normally increase.

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[4] U.S. Environmental Protection Agency, "Policy on Storage and Releases for Water Quality Control in Reservoirs Planned by Federal Agencies," Appendix: Assessment of Adequate Treatment for Implementation of EPA Flow Regulation Policy, 16 January 1973.

[5] Skogerboe, G. V., "Role of Water Delivery Systems in Water Quality," Age of Changing Priorities for Land and Water, Irrigation and Drainage Division Specialty Conference, Spokane, Washington, 1972, p. 105.

It is important that present water quality and water uses in the stream reaches affected by proposed increases in irrigated agricultural land are clearly identified and quantified. It should be noted also that continuous irrigation over long periods of time may ultimately result in elevated groundwater levels and salt buildup to the point where crops can no longer be grown. Most irrigation return flows are not now treated and may not be economically treated in the near future so that increases in salinity, nutrients, sediments and other pollutants may be expected. However, good irrigation practices can minimize the adverse impacts on the water quality of the return flow.

A.3 Assessment of Impacts

Key to assessing changes in land use and impacts is the ability to judge the suitability of lands for supporting the type and intensity of growth which might be induced by the project. The quantities of water made available for water supply and irrigation may be directly converted to population or land area equivalents, for example. Not only the magnitude but also the probable phasing of such development will influence how well environmental quality can be maintained during the induced growth period. If the supply of water to a city in essence removes a major growth constraint, development may proceed more rapidly than in an area not up against a limit of water availability. Local and regional water and air quality conditions and goals may serve as important indicators to assess the desirability of further growth in particular areas. The existence of environmental quality or pollution problems should be interpreted as a signal that natural resources are being overutilized and overstressed.

Extensive shoreline development may threaten water quality and increase the potential for eutrophication in an impoundment. In assessing the adequacy of an EIS discussion of land uses and impacts around a proposed reservoir, consideration must be given to ensuring maximum protection of water and environmental quality. Because nutrients from septic tank-leaching field systems can be readily transported through the soil to a reservoir, public sewering of developable shoreline areas should be fully evaluated. Requirements for a minimum setback distance might also be recommended. If proposed federal land acquisition for the project leaves large sections of shoreline open to private development, extension of public ownership to further protect water quality and maintain open space may be necessary or desirable.

In many cases development will occur downstream from an impoundment due partially to the increased flood protection afforded by the presence of the dam. Under Executive Order 11296 federal agencies are responsible "to provide leadership in encouraging a broad and unified effort to prevent uneconomic uses and development in the nation's flood plains...." EPA feels it appropriate to advise agencies on preventative as well as recovery tactics. The EIS should provide information on requirements for local cooperation in zoning and planning in flood plains. If the EIS claims flood control benefits for structures which are expected to locate in the flood plain below the dam at some time in the future, it is inconsistent with the policies stated in Executive Order 11296.

In the case of irrigation where definite modifications of land use are more easily identified, the assessment of impacts can be more specific. Water used in irrigation may reenter a stream either as a point source discharge (drainage return flow) or nonpoint discharge (surface runoff). The latter may be controlled best by proper land management and good irrigation methods, including mulching, contour planting, terracing, careful regulation of the amount of water applied, and suitable fertilizer and pesticide application techniques. The salinity of the soils in areas to be irrigated has an important influence on the water quality of return flows. It might be feasible to avoid irrigating those areas where soils are formed from shales or are high in natural salts if other land is available. Any methods which reduce evaporation and transpiration losses aid also in limiting salinity increases. Drip or "trickle" irrigation and subsurface irrigation systems offer a number of advantages over furrow or sprinkler systems, among them reduction of evaporation and resultant salt concentrations and a high degree of water and nutrient control.[6] Presently, treatment of drainage water for removal of minerals and salts is considered infeasible except in special situations:

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[6] Wells, D. M., Chrmn., "Agricultural Waste Management, by the Committee on Agricultural Waste Management of the Environmental Engineering Division," Journal of the Environmental Engineering Division, ASCE, Vol. 100, No. EE1, February 1974, pp. 1-6.

> **Special situations are deemed to be where high-value crops are grown in a water-short area and where brine disposal would be relatively inexpensive or where the treatment would be carried out in combination with the production of power or some other process generating large amounts of waste heat.[7]**

The development of irrigated agriculture may degrade water quality in streams receiving drainage water such that water quality requirements of certain water users would no longer be met. Raw water sources for public supplies should not contain more than 250 mg/l of either chloride or sulfate unless no other source containing less than that concentration is available.[8] Maximum acceptable concentrations for nitrate and various pesticides are described in EPA's Proposed Interim Primary Drinking Water Standards. Certain industrial users may have fairly rigid water quality requirements that may not be met after the addition of irrigation drainage water without extensive additional investment in water treatment facilities. The reviewer should consult Section V of Water Quality Criteria for further information on water quality characteristics and requirements for various industrial classifications.[9]

Any practices that result in more efficient use of irrigation water may reduce water quality degradation due to return flows. Subsurface irrigation may produce comparable crop yields with as much as 40-50 percent less water than is required with furrow irrigation.[10] Installations of lined canals or closed conduit conveyance systems will reduce seepage losses, salt pickup and evapotranspiration losses due to phreatophytes, and conduits have the added advantage of reducing direct evaporation losses. Tile drains designed to intercept less saline groundwaters will minimize deep percolation losses and reduce water quality problems due to salts. A pumpback system for tailwater control increases the efficiency of water use and minimizes pesticides, phosphorus and heavy metals in the return flows. The EIS should contain descriptions of how the irrigation system will be operated, what provisions will be made for monitoring water use and quality at individual farms, and how pollution from return flows will be minimized. Plans to implement land treatment programs and other water quality protection measures should be fully described in the EIS, along with the agencies responsible for implementation. The publication "Evaluation of Salinity Created by Irrigation Return Flows" discusses irrigation water quality problems and control methods in greater detail and should be consulted if further assessment information is needed.[11]

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[7] U.S. Environmental Protection Agency, op. cit., Appendix p. 10.

[8] U.S. Environmental Protection Agency, "Proposed Criteria for Water Quality, Volume I," Washington, D.C., 1973, pp. 200, 213.

[9] National Technical Advisory Committee, FWPCA, Water Quality Criteria, Washington, D.C., April 1, 1968, pp. 185-215.

[10] Jenke, A. L., "Evaluation of Salinity Created by Irrigation Return Flows," U.S. EPA, Office of Water Program Operations, Nonpoint Source Control Branch, Washington, D.C., January 1974, 128 p. (EPA 430/9-74-006).

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[11] Ibid.

B. Review of Water Quality and Ecological Impacts

Potential water quality and ecological impacts are related basically to the direct and indirect environmental changes caused by the project. Three general but interrelated areas of influence can be identified: (1) the impounded water body, (2) the river downstream from the dam, and (3) areas of impoundment-related land use change. The latter is discussed in greater detail in Section IV.A, Land Use Impacts, since effects do not originate directly from the land and water resources that are physically altered by an impoundment project.

Of the many water quality changes that take place in an impoundment, effects on temperature, dissolved oxygen, dissolved and suspended solids, flow, and bacteria are usually the most important with respect to water uses and ecology. Certain impacts can, in general, be expected and described in relation to particular site characteristics, upstream conditions, and proposed reservoir operations. However, quantification of impact magnitudes and significance may be difficult, other than to say that an effect probably will or will not occur. Water quality and related ecological impacts are obviously major issues for impoundments, requiring careful review and coordination with agencies having specific interest and expertise in these areas. Guidance presented herein may be supplemented by reference to the cited technical publications or through appropriate EPA offices.

B.1 Sources of Impacts

Impacts on water quality and ecology can be associated with impoundment construction, inundation of land areas and creation of an artificial lake, and operational procedures and water uses that have an influence both in an impoundment and downstream. In all cases, impacts to water quality in the impounded water body and the river downstream from the dam should be related to applicable state and federal water quality standards and criteria, as discussed further in Section IV.B.3.

B.1.a Impoundment Construction

Sediment, pesticides, petroleum products, and other materials are potentially significant water pollutants at an impoundment construction site. These are described briefly below, with further information available in Section 6.0 of "Methods for Identifying and Evaluating the Nature and Extent of Nonpoint Sources of Pollution."[1]

Sediment. A major source of water pollution at an impoundment site is construction-generated sediment which is transported primarily by water and to a lesser extent by wind. Erosion of land areas disturbed by construction activities is dependent on many factors including the characteristics of the soil, climatological conditions, and topography of the site, particularly in areas where clearing and excavation are to take place.

During the construction of an impoundment, any of the following activities may be potential sources of sediment pollution.

(1) Site preparation--clearing, grubbing;
(2) earthmoving (cutting, filling and stockpiling);
(3) construction and removal of cofferdams or other diversion structures or stream relocation;
(4) relocation of existing facilities;
(5) dredging;
(6) access and haul road construction and use;
(7) removal of material from borrow areas;
(8) rock blasting, drilling, tunnelling or channelling;
(9) dam foundation preparation and placement of materials;
(10) landscaping and general site clean-up operations; and
(11) sediment control pond discharges.

Wash water from processing stone aggregate and concrete batching, placement, curing and cleanup operations are other common sources of sediment.

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[1] U.S. EPA, Office of Air and Water Programs, "Methods for Identifying and Evaluating the Nature and Extent of Nonpoint Sources of Pollution," Washington, D.C., October 1973 (EPA 430/9-73-014).

Pesticides. Depending on the type of dam and ultimate use of the impoundment, a number of chemical compounds may be used at the impoundment construction site to control the growth of aquatic vegetation, kill or retard growth of vegetation around the impoundment (dam faces), or suppress insect populations (primarily mosquitoes which breed in standing water).

Petrochemicals. Gasoline, diesel fuel, and lubricants are the major petroleum products used at construction sites. Potential pollution problems may occur from any of the following:

(1) Storage depots (accidental spills);
(2) leaky vehicles (crankcase oil, gas lines, seals and hydraulic lines);
(3) road oiling (reduces dust);
(4) disposal of waste oils onto the ground (crankcase); and
(5) spillage when filling vehicles.

Petrochemicals are significant because they will form a film on the water surface, are odorous, and may adversely affect wildlife which contact the water surface.

Other Construction Activities. Other materials used at a construction site may be potentially harmful if introduced into waterways through spillage, improper disposal, or careless application. Some of the materials and operations which may create adverse environmental effects are the following:

	Activity	Materials Used	Potential Effect on Waterbody
(1)	Cleaning masonry surfaces	usually acids	lower pH
(2)	Landscaping	lime, fertilizers	raise pH, eutrophication
(3)	Other cleaning agents, solvents	kerosene, toluene, turpentine, etc.	may be toxic to fish and other biota

The EIS should identify potentially toxic or hazardous chemicals to be used and application rate, particularly when used adjacent to or in waterways.

Sanitary Wastes. Four basic methods for handling sanitary wastewater at the impoundment construction site may be used: (1) pit privy, (2) chemical toilet, (3) holding tank, and (4) septic tank and leaching field. None of these systems should present a pollution hazard under normal conditions, provided that the facilities are properly located and maintained. Areas with steep slopes, high water table, or poorly draining soils, and sites subject to flooding or heavy runoff should be avoided.

B.1.b Inundation of Land and Creation of Artificial Lake

Replacement of a freely flowing stream with a lake environment, inundation of land, and altered hydraulic characteristics represent the principal sources of water quality and ecological impacts in an impoundment. Beyond these basic changes, thermal stratification, sedimentation, expected land use around the reservoir and inflowing water quality all affect the physical, chemical and biological properties of the impounded water. The impacts described below are likely to occur at many impoundment projects, and the EIS should be reviewed with adequate consideration given to these effects.

Impacts Due to Land Inundation. The nature and composition of vegetative cover and soils within a proposed reservoir area can influence the overlying water quality subsequent to impoundment. Water quality changes resulting from initial inundation of the reservoir and continuing for varying periods up to several years, may affect both withdrawal (consumptive) and downstream uses of the water. At most impoundments, even some large and deep ones, the following changes are likely to be evident for a few years: substantial depletion of dissolved oxygen, organic enrichment, increases in iron, manganese, nutrients, and other dissolved substances, and increased algae growth.

These changes in water quality result from the following processes:[2]

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[2] Sylvester, R. O., and R. W. Seabloom, "Influence of Site Characteristics on Quality of Impounded Water," Journal of the American Water Works Association, 57:1528-1546 (December 1965).

(1) Ion exchange through the clay and humic colloids in the soil under water-saturated conditions.

(2) Microbiologic degradation of organic materials, which releases dissolved materials and carbon dioxide.

(3) Leaching of organic and mineral substances from the soil or vegetation.

(4) Microbiologic activity at the soil-water interface, which depletes dissolved oxygen possibly causing anaerobic conditions and a change in the products of decomposition.

Submergence of vegetative matter and other organic debris causes an oxygen demand through microbiologic activity which, in the initial years of filling and operation, may be sufficient to deplete dissolved oxygen or even produce anaerobic conditions in parts of a reservoir. In many impoundments, the reduction of dissolved oxygen due to organic decomposition and leaching alone will be significant for only one or two years; however, the effect is the same as the addition of an external waste source. Downstream waste assimilative capacity or intended water uses may be temporarily impaired.

Associated with an oxygen-deficient environment at the bottom of a newly created reservoir may be other biochemical reactions which also adversely affect overlying water quality. Under normal, oxygenated conditions, iron and manganese are only slightly soluble and form precipitated complexes with phosphate and other substances, whereas in anaerobic waters, the complexes are reduced to free iron, manganese and phosphate into solution.[3]

Land flooded by an impoundment is lost as habitat for terrestrial wildlife. Areas exposed by seasonal drawdown or subject to recurring inundation from flood control operations may have significantly reduced value ecologically. Inundation may destroy wildlife or plants of special significance because of their rarity or uniqueness. Decomposition of organic matter and solution of nutrients are likely to create an initially very high rate of productivity in the reservoir, which may decline after several years.

Alteration of Assimilative Capacity. The creation of an impoundment on a previously free-flowing stream can substantially alter the capacity to assimilate oxygen-demanding wastes introduced either into upstream reaches above the dam or to downstream sections. With respect to basin-wide water quality management and planning, changes in reaeration rates, travel times, and flow and temperature regimes within the impoundment's zone of influence may have far-reaching effects on optimal waste loading and allocation.

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[3] Ibid.

The assimilative capacity of a water body is most usefully defined in terms of the waste load that can be introduced without degrading the water below a minimum acceptable quality for a certain water use. A variety of factors combine to determine the assimilative capacity of a stream; as any of the factors change, so does assimilative capacity. Among the primary determinants are:

(1) flow, which affects the amount of dilution a waste will receive;
(2) stream gradient and depth, which affect vertical mixing and turbulence;
(3) surface area of water exposed to atmospheric reaeration;
(4) temperature, which affects the saturation concentration of dissolved oxygen and BOD reaction rate;
(5) "background" BOD or concentration of organic wastes;
(6) dissolved oxygen concentrations present, which affect gas transfer at the air-water interface; and
(7) biological characteristics.

The items listed above are very much interrelated in terms of their effects on waste assimilative capacity and all can be drastically altered by impounding and regulating a freely flowing stream. Altered conditions in an impoundment can substantially affect the application and basis for interpretation of stream standards, water quality criteria, waste load allocations, and other regulatory and planning devices for water pollution control. Existing EPA-approved state water quality standards recognize the variability of assimilative capacity with the above-listed factors, and interpretation of the standards is generally based on the average minimum consecutive 7-day flow to be expected once in 10 years. Such low flow generally coincides with the warmest season of the year when water temperatures are at or near their highest annual levels, thus defining the critical water quality period with respect to assimilation of wastes. In general, the reviewer should recognize that upstream sources of pollution, including both nonpoint sources and treated wastewater effluents, will often create poorer water quality conditions in an impounded stream segment than in an unimpounded reach.

In reservoirs that become thermally stratified in the warm months, the inflowing stream will seek its own density level and may move as an interflow or underflow rather than staying in the epilimnion where waste assimilative capacity is decidedly greater. Such density currents are primarily the result of temperature differences, although dissolved solids and suspended solids may also cause density differences with depth. If the impoundment is used for flood control, highly turbid waters from heavy runoff may move through the reservoir as a distinct layer at a level determined by density. With respect to waste assimilative capacity, any inflowing water which sinks and spreads horizontally below the epilimnion is effectively removed from the two major sources of oxygen replenishment, reaeration by contact with the atmosphere and photosynthesis.

Under stratified conditions, water quality in an impoundment may be altered significantly, with important effects on aquatic biota. Parts of the total volume of the reservoir below the thermocline may be uninhabitable by fish if oxygen deficiencies develop. The magnitude of hypolimnetic oxygen depletion may be largely dependent on productive or eutrophic conditions in the epilimnion, from which dead algae and other organic matter sink and add to the oxygen demand (see section on eutrophication below). Nutrients may be released from bottom sediments when dissolved oxygen concentrations are low and recycled to the euphotic zone by mixing in the autumn, winter and spring.

Eutrophication. Eutrophication is the process whereby water bodies become enriched with nutrients, resulting in generally undesirable changes in water quality. Excessive growths of algae and sometimes higher aquatic plants characterize a eutrophic lake or impoundment. Although numerous elements are essential for the growth of algae, phosphorus and nitrogen are most likely to be in limited supply in natural waters.

The change in flow regime from a free-flowing stream to an impounded lake, results in the reduction of the assimilative capacity of the water body. This fact, combined with the inundation of land rich in nutrients and/or favorable nutrient influx conditions, may result in eutrophication of the impoundment. In addition, hard waters are more likely to be eutrophic than soft waters. Portions of the reservoir may exhibit the characteristics of eutrophic waters while other portions may not.

Eutrophication is essentially irreversible. Although numerous methods for restoring and enhancing water quality of eutrophic lakes are being used and researched, most are remedial and have generally limited long-term effectiveness. Therefore, the potential for eutrophication as well as possible preventive measures must be thoroughly analyzed in the EIS, since impacts associated with eutrophication are likely to detract from the usefulness of an impoundment. Impacts caused by eutrophication of an impoundment include the following:

--reduced water clarity;

--possible increase in water temperatures in the surface layers, due to increased turbidity;

--tastes and odors;

--increased water treatment costs for disinfection, filtration and coagulation in impoundments used for water supply;

--production of organic matter which contributes to dissolved oxygen deficiencies in the hypolimnion; and

--nuisance weed growths that interfere with boating and water contact sports.

Other Impacts. Other possible impacts in an impoundment are reduction of coliform bacteria and other potentially harmful microorganisms, reduction of sediment load, reduction of color, increases in salinity due to evaporation, and alteration of species composition and diversity. If widely fluctuating water levels are anticipated, erosion in the drawdown zone and impacts on fish spawning should also be considered.

The die-off of bacteria and reduction of color in an impoundment are usually regarded as beneficial effects. Although coliform bacteria may be carried into watercourses from soils and vegetation in the watershed, microorganisms in sewage effluent will generally be the greatest source of bacterial pollution, where such sources exist.

Increases in salinity in an impoundment will require consideration only for projects located in arid or semi-arid regions where high rates of evaporation are anticipated, or where dissolved solids concentrations in inflowing streams are high. Salinity problems presently are of greatest concern in the seventeen western states and most often result from irrigation drainage and water loss. High salinity may make a water source unpalatable or even unacceptable, from a health standpoint, for public supply. Also, water with high dissolved solids concentrations contributes to salt build-up in irrigated soils, may damage plants, and must be applied in greater quantities to maintain a salt balance.

Impoundment of a stream almost invariably reduces the diversity of the aquatic ecosystem; that is, fewer species will inhabit an artificial lake than were found in the stream prior to impoundment. The total number of organisms present, however, is likely to be greater than in the stream because of expanded aquatic habitat in a reservoir. It is probable that, with time, the species composition will change. In many cases, impoundments become overpopulated with rough fish and management for more desirable game species may be difficult. This adjustment, although adversely affecting recreational fishing, serves to maintain an ecological balance and for the most part is unavoidable.

Increased depth and decreased water velocities in an impoundment cause sedimentation of suspended material on the reservoir bottom. These changes may eliminate or severely reduce populations of benthic organisms and insects that are adapted to a stream environment. Improved water clarity due to sedimentation of suspended matter allows greater light penetration, possibly enhancing productivity of an impoundment and stimulating growth of aquatic weeds in shallow areas.

B.1.c Downstream Impacts from Impoundment Operation

Primary and secondary ecological impacts downstream from an impoundment can be traced essentially to: (1) changes in physical, chemical and biological quality and (2) changes in water quantity and flow regime. Alterations of nutrient supply, dissolved oxygen, temperature and sediment load along with flow changes are usually the most important factors to be considered with regard to downstream impacts. Obviously, changes in chemical and biological water quality that take place in an impoundment will influence downstream conditions, although factors of flow, outlet location, season, and size and morphometry of an impoundment will also affect stream quality. The impacts described in this section are encountered at many impoundments, and they should be addressed in the EIS.

Impacts on Water Quality and Assimilative Capacity. The uses of a reservoir determine to a large extent the changes in a river's flow regime that will accompany operation of the project. Along with artificial variations in flow, the quality of released waters, hydraulic characteristics of the river, and other factors influence downstream water quality. Much of the technical literature concerning the impacts of impoundments on downstream waste assimilative capacity and water quality focuses on thermally stratified impoundments used for, among other purposes, the generation of electrical energy. Many problems similar to those associated with hydroelectric power generation may, however, occur at other impoundment projects as well.

Because hypolimnetic waters in deep, stratified reservoirs are often depleted of dissolved oxygen, their release through deep outlets or power penstocks may degrade water quality downstream. Hypolimnetic water quality may deteriorate progressively from the onset of stratification such that, by the critical water quality period in later summer or early autumn, low concentrations of dissolved oxygen and possibly high BOD, iron, manganese and dissolved solids accompany reservoir discharge.

The same factors causing changes in reaeration in the upstream backwaters of an impoundment affect the replenishment of dissolved oxygen in downstream reaches. A zone of high turbulence is usually created in the tailrace below a dam by deflectors, hydraulic jump stilling basins or other energy dissipation devices. However, the short time of turbulent contact may not be sufficient to induce significant reaeration. Below the tailrace section, velocity decreases and depth increases, both of which work against increases in reaeration. Kittrell observed that high discharge rates with deep flow and short times of travel allowed a minimum of reaeration.[4] Although it is possible that a greater total quantity of dissolved oxygen would be transferred during periods of high discharge below a dam, the concentration of DO is of interest for protecting downstream aquatic life and assuring good water quality for other uses.[5] Churchill found that dissolved oxygen concentrations in the Holston River below Cherokee Dam were consistently and significantly lower at higher discharge rates associated with hydroelectric power generation.[6] Such conditions should be anticipated in impoundment projects which create large, deep reservoirs with low-level intakes. Methods for predicting, as well as techniques to minimize or avoid adverse effects of impoundment on downstream water quality are discussed in greater detail in Sections IV.B.2 and IV.B.3.

Besides the possibility of low dissolved oxygen and reduced waste assimilative capacity, other probable water quality effects may include:

--raising or lowering of downstream water temperatures;
--changes in nutrient and dissolved solids concentrations;
--nitrogen supersaturation (if large spillway discharges are expected);
--decrease in sediment load; and
--decrease of coliform bacteria.

The magnitude and significance of these effects depend on associated flow regimen variations and on downstream consumptive and nonconsumptive uses of water. Increased water treatment costs may be necessitated by increases in iron, algae, or other undesirable constituents, and a stream's aesthetic value may be altered. Major factors influencing downstream water quality changes are the existence and extent of thermal stratification in a reservoir, outlet location, upstream water quality and the extent and timing of artificial flow regulation.

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[4] Kittrell, F. S., "Effects of Impoundments on Dissolved Oxygen Resources," Sewage and Industrial Wastes, Vol. 31, No. 9 (September 1959), p. 1070.

[5] Ingols, R. S., "Effect of Impoundment on Downstream Water Quality, Catawba River, S.C.," Journal of the American Water Works Association, 51:42-46 (January 1959).

[6] Churchill, M. A., "Effects of Impoundments on Oxygen Resources," pp. 107-124 in Oxygen Relationships in Streams, Cincinnati, Ohio, Technical Report W58-2, Taft Sanitary Engineering Center (March 1958).

Impacts on Stream Ecology. Many organisms have very definite habitat requirements for survival, growth and reproduction that may be affected adversely or beneficially by construction and operation of an impoundment. When analyzing the ecological impacts the reviewer should keep in mind that the effects of one factor on biota may be either negated or magnified by another. For example, cool water releases to enhance salmon or trout spawning may be ineffective unless the concomitant discharge magnitude and timing are sufficient to provide proper stimuli and maintain suitable spawning beds. Evaluation of probable ecological impacts is largely contingent on the kind and amount of information presented in the EIS about the existing ecosystem, important species, proposed operating criteria and procedures, and future water uses above and below the impoundment site. Ecological impacts of various impoundment-induced changes are identified below.

Temperature--Decrease in temperature from low-level releases at a stratified impoundment may reduce the numbers and diversity of fish, insects and other organisms whose life cycles do not conform with colder water temperatures during the summer. Overall productivity in the stream may decline due to the temperature-dependence of many chemical and biochemical reactions. On the other hand, cold water releases may enhance a trout fishery and other life forms that require or can adapt to cooler water temperatures. High-level releases may warm the stream excessively and have detrimental effects on some species. In particular, increase in temperature from the release of warmer epilimnetic waters during the summer may adversely affect coldwater species.

Dissolved oxygen (DO)--Reduction of DO concentrations normally accompanies deep releases from stratified reservoirs. The tolerance of different organisms to low DO levels varies substantially. If channel gradient and stream depth are such that a DO deficit persists for some distance downstream, a shift to more pollution-tolerant species may occur. Low dissolved oxygen concentrations would have a greater adverse impact on trout, migrating salmon and other generally valuable species than on some warmwater biota.

Nutrients--An impoundment usually reduces the total nutrient input to downstream reaches due to utilization by algae and entrapment in bottom sediments. However, the downstream nutrient load may deviate considerably from concentrations observed in inflowing waters. In particular, discharge of nutrients may be high during stratification if concentrations build up in the hypolimnion under reducing conditions and discharge water is drawn from deep parts of the impoundment. Variations in nutrient concentrations affect autotrophic organisms such as algae that form the basis of the food chain.

Sediments--Reduction of sediments in water passing through an impoundment improves water quality downstream. This change may enhance productivity by increasing light penetration, especially if the stream is highly turbid in its preimpoundment state. In stratified reservoirs, turbid water may move in distinct layers which, if they coincide with the discharge level, may cause downstream turbidity problems over a longer time period. Depending on flow regime, scouring of the stream channel and bank erosion may increase as a new equilibrium sediment load is attained. The stream reach below the dam may, in a short time, be degraded for a considerable distance. The stream may also be turbid for longer periods of time and more frequently below an impoundment. If high flows are significantly reduced or eliminated, sediment may deposit on the stream bottom, causing impacts on bottom-dwelling organisms and fish spawning.

Flow--All of the above factors may be affected by flow. Ecological impacts depend on the timing, duration and magnitude of flow regime changes and coincident water quality conditions. Within the general area of flow regime modification, the functioning of a dam as a physical barrier to upstream movement of migratory or anadromous species should be viewed as a potential source of ecological impacts.

B.2 Review of Impact Quantification

It should be noted at the outset that quantification of water quality and ecological impacts following impoundment is a highly complex task, particularly in the case of reservoirs that are expected to exhibit strong thermal stratification. Numerous mathematical modelling techniques may be used for prediction of postimpoundment water quality, both in the reservoir and downstream. Yet all such models have inherent limitations due to the need for various simplifying assumptions and the inability to verify results until data from the operating reservoir are available. In any quantitative methods used to describe flow or water quality variations for a proposed impoundment, it is essential that all assumptions and techniques leading to predictions are identified, either in the EIS or in appropriately referenced planning or study reports that should be available to the reviewer. In addition, and perhaps more importantly, the degree of reliability or confidence associated with any such estimates should be stated to avoid misinterpretation. The time frame of analysis may also have particular importance. If, for example, estimates of downstream releases or water temperature are presented as monthly averages, the possibility of significant daily, weekly or erratic deviations from mean values because of reservoir operations should not be overlooked.

The following three sections describe the kinds of analyses and impact quantification techniques that should be looked for in EIS's on impoundment projects. Guidance is also given for relating project scope, physical features, and environmental characteristics to the magnitude and importance of various impacts.

B.2.a Impoundment Construction Impacts

The potential for water pollution at an impoundment construction site is in most cases directly related to the scale of construction operations. Relevant considerations include the amount of land area to be cleared or cleared and grubbed, the location and size of excavation, borrow and fill areas, the extent of highway and railroad relocations, and the scheduling of various work items.

Numerous quantitative methodologies for determining erosion and sediment generation can be found in the literature, several of which are summarized in "Methods for Identifying and Evaluating the Nature and Extent of Nonpoint Sources of Pollution."[7] Application of these techniques, however, requires considerable data and assumptions that would not generally be obtainable from an impoundment EIS. In reviewing potential water pollution impacts from impoundment construction, the focus should be on pollution control, as well as quantification of effects. Enforcement of definitive environmental protection specifications and appropriate federal, state and local regulations should minimize water pollution hazards.

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[7] U.S. EPA, op. cit., Section 6.6.

There are no generally available techniques for quantifying water pollution caused by impoundment construction, other than for soil erosion. However, the potential for water pollution from chemicals used at the site is a function of the scope of the construction project and size of the stream. For example, spillage of a certain quantity of oil is likely to have greater adverse impact on water quality and stream biota in a small brook than in a large river. Also, the larger an impoundment, the greater will be the area of soil disturbance and quantity of various chemicals used at the construction site.

Except in the event of direct spills to the watercourse, chemical pollutants will often be transported along with sediments by erosion. Sedimentation due to construction may not be evaluated quantitatively in the EIS, but rather be addressed in construction specifications limiting turbidity increases in the stream. Estimates of process water and runoff volumes used in the design of treatment systems for removal of turbidity or other pollutants should be stated in the EIS and compared to low-flow stream conditions. If projected wastewater volumes are large relative to streamflow, pollutants contained in process waters and runoff from exposed areas may have a significant impact on stream quality.

Although quantification of construction impacts is difficult, knowledge of the magnitude of construction operations and stream characteristics and uses will help the reviewer to estimate whether significant pollution potential exists and whether proposed measures for protecting water quality are adequate.

B.2.b Impacts of Land Inundation and Creation of Artificial Lake

Several quantitative methodologies for predicting water quality or designing project facilities (such as selective withdrawal outlets for control of downstream water temperature and/or quality) may have been used to support conclusions reached in the EIS. Predictions of reservoir temperatures and the discharge thermal regime, dissolved oxygen, perhaps certain chemical parameters and, for multilevel outlets, hydraulic and withdrawal zone characteristics are often made. All of the federal impoundment and water-related agencies have conducted considerable research on the effects of impoundments on water quality, but most modelling approaches are derived from certain fundamental principles. Data requirements, assumptions, applicable conditions and validity of results for selected reservoir water quality models are summarized in Section III of An Assessment Methodology for the Environmental Impact of Water Resource Projects.[8] The section discusses models for prediction of reservoir and downstream water temperatures, dissolved oxygen in reservoirs and streams, and nitrogen, phosphorus and toxic compounds. The primary references cited should be consulted for further information on specific models. Other authors[9-12] have described models of reservoir hydraulics and selective withdrawal outlets as well as their relationship to downstream water quality.

In the absence of water quality modelling studies, it is nevertheless possible to get a reasonably good indication of the postimpoundment water quality characteristics and possible impacts by studying: (1) site characteristics, including vegetative cover types, soils, topography and morphometry, (2) existing stream quality data, (3) design and operational characteristics such as anticipated modification of natural flows, reservoir fluctuations, depth of outlets and (4) project purposes and stream and water uses. The following paragraphs discuss use of information in these various categories in quantifying or estimating potential water quality impacts at proposed impoundments.

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[8] Warner, M. L. et al., An Assessment Methodology for the Environmental Impact of Water Resource Projects, prepared for U.S. EPA, Office of Research and Development, Washington, D.C., July 1974, (EPA-600/5-74-016), pp. 28-85.

[9] Bohan, J. P., and J. L. Grace, Jr., "Selective Withdrawal from Man-Made Lakes," Technical Report H-73-4, U.S. Army Engineer Waterways Experiment Station, Hydraulics Laboratory, Vicksburg, Mississippi, March 1973, 28 p.

[10] Brooks, N. H. and R. C. Y. Koh, "Selective Withdrawal from Density-Stratified Reservoirs," Journal of the Hydraulics Division, ASCE, Vol. 95, No. HY4 (July 1969), pp. 1369-1400.

[11] Imberger, J., and H. B. Fischer, "Selective Withdrawal from a Stratified Reservoir," prepared for U.S. EPA, Water Pollution Control Research Series (15040 EJZ 12/70), December 1970, 104 p.

[12] Wunderlich, W. O., and R. A. Elder, "Effect of Intake Elevation and Operation on Water Temperature," Journal of the Hydraulics Division, ASCE, Vol. 95, No. HY6 (November 1969), pp. 2081-2091.

Impacts Due to Land Inundation. For a period of from one to several years after an impoundment is initially filled, overall water quality in the reservoir will be affected more strongly by the characteristics of the newly inundated bottom land area than by inflowing water. The designated uses of the impounded water and the stream below the dam, along with applicable water quality criteria supporting such uses, will define acceptable limits for various water quality constituents which would be subject to change as a result of impoundment. If a portion of the reservoir storage is allocated to public water supply or low-flow augmentation, the impounded water quality will be critically important to the values derived from these water uses. Pursuant to Section 102 of the FWPCA, it is the responsibility of EPA to determine the value of flow augmentation for water quality control for projects authorized after the Act was passed.

In order to estimate the impact of impoundment area conditions on future water quality, information concerning the location and extent of various types of soil and plant cover is basic. Knowledge of land uses, such as presently cultivated and abandoned agricultural fields and pasture, gives some indication of potential nutrient supplies to the overlying water following inundation. Forest and brush land, while generally a smaller source of nutrients for algal growth in the initial years of impoundment than fertilized farm land, can contribute to an overall deterioration of water quality, particularly with respect to dissolved oxygen (DO), color and dissolved materials. It is important that land uses within an impoundment are fully described and quantified in the EIS, using reservoir maps to depict areas and tabulations to indicate percentages of the total floodable area. Agricultural land, marshes, swamps, and other areas rich in organic matter or nutrients can be expected to degrade water quality more than less fertile sites such as coniferous forest areas.

Iron and manganese problems would most likely be encountered at impoundment sites exhibiting a large proportion of organic soils such as muck or peat, and vegetative matter in the area to be flooded. Such site characteristics will also influence the initial and perhaps the longer-term productivity of the impoundment as phosphates, nitrogen compounds and other inorganic nutrients could be released from the underlying soils. Initially high rates of biological productivity in newly created impoundments are thus characteristic of organically enriched sites with settling and decay of algal cells possibly compounding the oxygen deficiency in the lower strata. The maintenance of reservoir fertility after the nutrient supply originating from inundated soils and plants is stabilized depends primarily on inputs from upstream sources, recycling from accumulated bottom sediments and the amounts of nutrients discharged from the reservoir. Algal blooms, which depend in part upon nutrients released from bottom material, are capable of producing more water quality changes than any other single factor.

The potential for water quality deterioration due to soils and vegetation that will be flooded should be investigated carefully. The reservoir soils should be classified at least according to their organic content and general areal extent. An arbitrary classification scheme could be: trace to 20 percent, mineral soil; 20-50 percent, organic soil (muck); and 50-100 percent, organic soil (peat).[13] Additional tests should include subjection of reservoir soils to water-soil contact under laboratory conditions to predetermine their effect per unit area on overlying water. Recommended analyses include DO, color, nitrate, ammonia, algal counts and pH measurements for at least one month.[14] Soils within proposed drawdown areas will be subject to alternate exposure and inundation; their erodibility will influence turbidity in the impoundment. Wave action and changes in soil pore pressures are likely to cause sloughing or landslides, particularly on steeper, unvegetated slopes. Such field studies and soil analyses are essential for estimating possible water quality problems and for evaluating the necessity of special site preparation measures, beyond the usual clearing.

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[13] Buckman, H. O. and N. C. Brady, The Nature and Properties of Soils, The MacMillan Co., New York (6th ed., 1960).

[14] Sylvester and Seabloom, *op. cit.*, p. 1544.

The general topography and morphometry of an impoundment may have considerable influence on its subsequent water quality characteristics. The effect of morphometry on stratification is most important, but several other factors that bear on water quality and related problems can be identified.

Erosion in Drawdown Zone. As a general rule, the steeper an area subject to recurring inundation or drawdown, the greater is the threat of substantial erosion problems. From a detailed topographic map of the proposed impoundment, an estimate of the amount of land within the inundation/drawdown area that could pose special stability problems can be made. The contour map would also allow correlation of erosion-prone areas with different flood heights and frequencies. Information on magnitude and frequency of water level fluctuations contained in the EIS should be translatable into pool elevations and inundated areas. The design flood, which would fill the reservoir to or above spillway crest elevation, may have a recurrence interval of several hundred years, whereas pool stages expected on an average of once in two years or five years would clearly define the reservoir area that might be subject to severe erosion problems on a regular basis. The season in which flood control operations are expected should also be noted. Winter floods sometimes occur due to unseasonably warm temperatures and, with subsequent refreezing before the flood pool is drawn down, ice may be an additional erosive agent.

As an example, if much of a project's flood storage capacity is derived from shallow inundation of flat bottomland and steeper hillside areas are only rarely subject to flooding, erosion may be less severe than at a reservoir confined largely to a narrow valley where slopes are submerged every year during flood control operations. Also, if the reservoir valley is oriented so as to coincide with the prevailing wind direction at the site, the potential for shoreline erosion by wave action is greater than if crosswinds predominate.

Other features of the flooding/drawdown zone, especially vegetation and soil types, may also affect the potential for erosion. Borrow areas and agricultural land within the flood pool limits may be very susceptible to erosion and should be identified on the reservoir map. Loose, unconsolidated soils also erode easily, particularly if vegetation is sparse. At some New England flood control impoundments, erosion of sandy soils in pine-forested areas is troublesome, compounded by undermining of the roots, loss of trees and further exposure to erosive forces. Clay content may promote flow or slippage of the soil when wetted by a rising flood pool. Although for the same parcel of land, heavy grass cover may offer better protection against erosion than forest cover, the factors of slope and flooding frequency should also be considered when viewing erosion potential at different locations in the reservoir.

As land in a flood control reservoir is inundated, the saturation of soils with water adds weight and may reduce cohesion. If the water freezes, expansive forces are exerted. These phenomena, in addition to the direct action of wind, ice and waves may enhance erosion by producing conditions favorable for localized slope failures, slumping or sloughing. In many instances, impoundment EIS's treat this subject in general terms, if at all. However, information on reservoir operation, topography, soils and vegetative cover should be available in the section describing the project and its environmental setting. With this data, a reasonable, site-specific estimate of at least the location and frequency of potential erosion problems due to water level fluctuations is possible. In addition to these factors, artificial cuts and fills associated with roads, highways and railroads that will be abandoned in the reservoir and subject to inundation may pose special erosion and stability problems.

Eutrophication and Aquatic Vegetation. The morphometry of a reservoir will also indicate where and to what extent aquatic weeds and algal blooms will occur and possibly create problems for water supply or recreation. Because sedimentation in the reservoir will increase water clarity (unless algal bloom conditions occur), areas of the proposed normal pool where water depths will be less than about 5 meters (15 feet) may be subject to aquatic weed infestations. An impoundment that covers a broad valley bottom may have far greater shallowly inundated area than a reservoir of the same capacity located in a deep narrow canyon. This comparison is illustrated by the area-capacity curves for two reservoirs, Figures IV-1 and IV-2, taken from EIS's.

Both the Crooked Creek Project and the Tellico Project would have volumes of 400,000 acre-feet (483,000,000 cu m) at respective surface elevations of 790

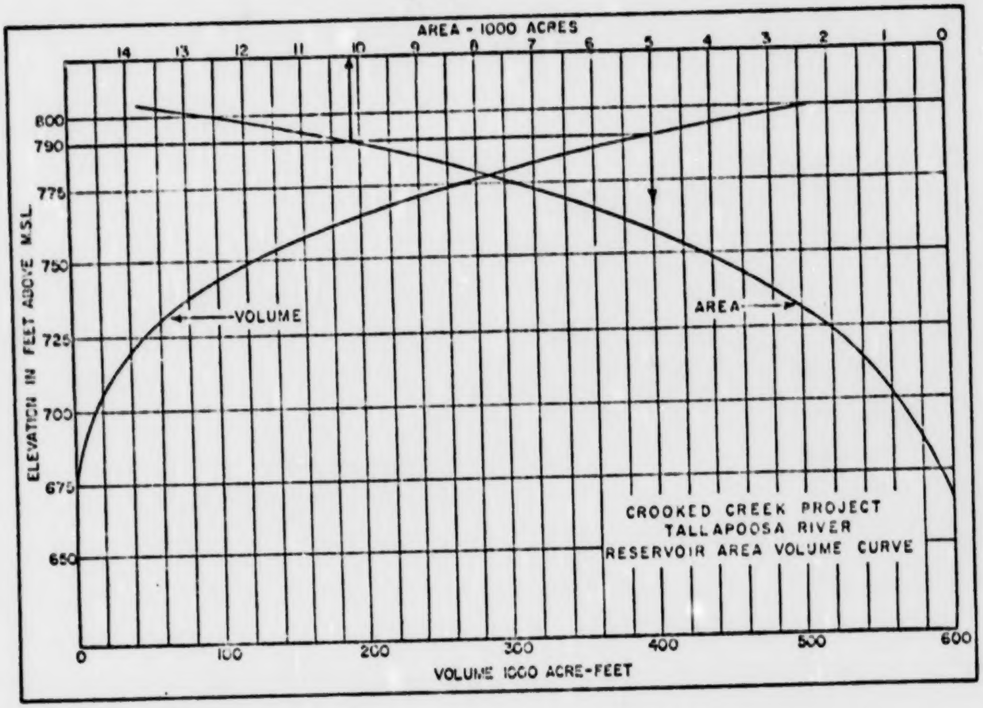

Figure IV-1: Crooked Creek Project Area-Volume Curve

Source: Federal Power Commission, Draft Environmental Statement, Crooked Creek Project No. 2628, Exhibit H, 2 March 1972 (NTIS PB 207 260-D).

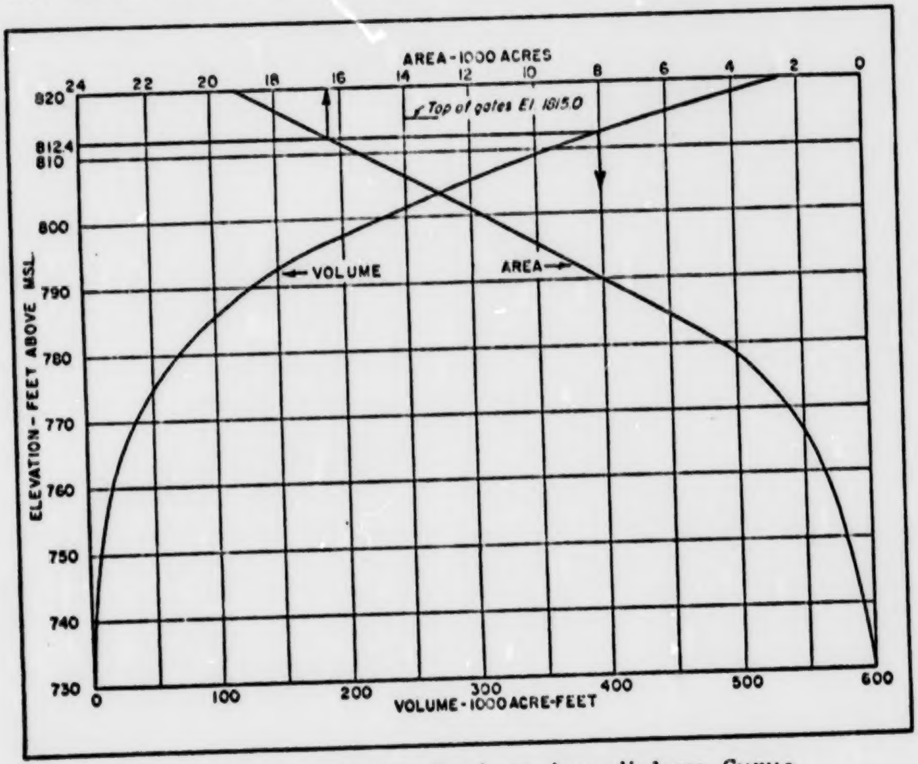

Figure IV-2: Tellico Project Area-Volume Curve

Source: Tennessee Valley Authority, Final Environmental Statement, Tellico Project, Vol. 2, 10 February 1972, pg. II-1-40 (NTIS PB 200 025-F2).

feet msl and 812.5 feet msl. Yet, for the given surface elevations, water depths of 15 feet (5 meters) or less cover only 2,750 acres (1,110 hectares) of reservoir bottom at the former, as compared with 5,400 acres (2,180 ha) at the Tellico Project. This information can be used in a number of different ways. Besides giving an indication of the extent of shallow areas, an area-capacity curve can be useful in interpreting and estimating water quality impacts associated with thermal stratification and hypolimnetic releases, as discussed later. Areas identified in this way as being susceptible to weed growth should be located on a reservoir map, whereby their proximity to proposed recreational developments (swimming beaches, cottages, marinas, etc.) can be ascertained and potential nuisance conditions identified.

Shallow areas, particularly in the upstream reaches of a reservoir, may also be subject to heavy sedimentation and build-up of undesirable bottom deposits, creating aesthetic and possibly water quality problems.

In addition to impoundment morphometry, other key factors which must be considered in evaluating the potential for eutrophication include: nutrient loading, presence or absence of temperature stratification, length of stratification period, latitude, retention time, land to be inundated, light and turbidity.

The major contributors to the nutrient load in an impoundment include: nutrient-laden influent streams, the entrance of runoff or seepage containing nutrients from areas surrounding the impoundment, and the land to be inundated. Modes of transport of nutrients into the lake include: surface water, groundwater, precipitation, nitrogen fixation, dry fallout, and wildlife. The most significant sources of nutrients entering most impoundments by various modes of transmission will usually be domestic wastes and/or agricultural runoff.

Information on the nutrient load as well as the morphometry, and mean depth of the reservoir will help the reviewer assess the potential for eutrophication. Depending on the conditions at the particular impoundment, the nutrient load may be minimized through regulation of pollutant sources. Reduction in the nutrient load should result in lowering the potential for eutrophication of the impoundment. It must be remembered, however, that there are a wide variety of factors which may be limiting in an impoundment.

In order to determine the potential for eutrophication, the EIS should provide data on the quality of the incoming water with regard to nitrogen, phosphorus, silica, carbonate and organics. Upstream point and nonpoint sources of nutrients should be identified. If water quality data indicate a potential for eutrophication of the impoundment under the existing influent conditions, methods of controlling nutrient input from upstream sources and the status of current EPA control measures should be described. If nutrient input is mostly from nonpoint sources, EPA has jurisdiction pursuant to Section 208 of the FWPCA. If nutrient input is mostly from point sources, EPA has jurisdiction under Section 402 of the FWPCA. The major issues involved here include the following:

(1) Nonpoint source nutrient input may originate from septic tanks, privies or cesspools located near the incoming stream and seeping into it. The state's sewage treatment plant grant priorities in the basin should be investigated to determine whether a reduction in the sanitary waste input may be forthcoming by construction of a sewage treatment plant which would take the place of the existing inadequate treatment. Another possible nonpoint source of nutrient pollution is agricultural runoff. This type of pollution is difficult to control. EPA must determine whether the nonpoint source contribution of nutrients is controllable in a reasonable period of time. This will involve investigation of current planning priorities in the basin. In addition, leaching of nutrients from surrounding land may contribute nutrients by seepage.

(2) Point sources which may contribute to the nutrient load of the stream should be identified in the EIS with sufficient data on their effluents to determine the feasibility of EPA's altering the plant's effluent discharge limitations to require a greater degree of treatment. Where a need exists EPA may wish to change the permit's treatment requirements from best practicable treatment (BPT) to best available treatment (BAT). Such an alteration of permit conditions would decrease the base load of nutrients in the influent stream, thereby decreasing eutrophication potential.

The EIS should provide data on development around the lake. Specific data on the types of sewage treatment facilities and the volume to be treated (per day) should be provided. All point source discharges to the lake should be identified. Allowances should be made for evaporation and concentration of nutrients in the impoundment.

The reviewer should combine the data on nutrient input sources and their location with the map of the impoundment to assess the potential for eutrophication in the impoundment as a whole. The reviewer should also attempt to assess the potential for problems of algal blooms or aquatic weeds in various areas of the impoundment. Among the factors which should be considered are: morphometry of the impoundment, drawdown practices, thermal stratification, and flow in the section of the impoundment being evaluated. For example, a long narrow reservoir may exhibit the characteristics of eutrophy in the upper sections and not in the lower sections if incoming water is rich in nutrients.

Groundwater could also account for a significant portion of the nitrogen loading in some lakes. Phosphorus input from groundwater usually accounts for a smaller portion of the phosphorus loading but may nonetheless be significant.

Alteration of Assimilative Capacity. The area, depth and volume relationships describing an impoundment project can aid in determining whether potential water quality and ecological impacts have been adequately addressed in an EIS. Several parameters can help determine whether thermal stratification should be expected. Among these parameters are: depth, period of storage, and climate.

The presence of oxygen-demanding wastes in influent streams is not necessary for oxygen deficiency in the hypolimnion of a reservoir. Many examples of significant dissolved oxygen depletion in reservoirs receiving water with negligible pollution have been cited.[15] Changes in water quality that take place in the hypolimnia of most stratified impoundments are detrimental to uses for public water supply and recreation, and may degrade downstream water quality if discharges are made through outlets below the thermocline. Although, as discussed earlier, prediction of water quality in stratified impoundments is most difficult, problems with dissolved oxygen deficiency, tastes, odors, high concentrations of iron and manganese and possibly hydrogen sulfide generation are quite likely to occur in any reservoir that is expected to thermally stratify and should be accounted for in the EIS.

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[15] Kittrell, op. cit., pp. 1069-1070.

It is not possible to specify numerical criteria or guidelines for levels of influent water quality parameters that will or will not cause deterioration of impoundment water quality. However, all upstream sources of both point and nonpoint pollution should be identified and resultant stream quality should be compared with applicable water quality standards. Treated effluents may be as important as other pollution sources, since conventional secondary treatment of sewage, for instance, has relatively little effect on nutrient concentrations. Basically, the existence of upstream wastewater discharges, extensive agricultural land use or large scale forest harvesting, should be a signal of possible water quality problems in stratified or large impoundments.

The assimilative capacity of an impoundment may differ significantly from that of a freely flowing stream, because of increased depth and surface area and decreased velocity. In general, the rate of atmospheric reaeration in a water body, as measured by the reaeration coefficient, is a direct function of average velocity and inverse function of average depth.[16] Therefore, an oxygen-demanding waste discharge entering the backwater area of an impoundment may cause a greater depletion of dissolved oxygen than would have occurred in the unimpounded stream. However, assimilation of the waste may take place over a much shorter distance.[17] Reaeration by the action of wind and waves as well as photosynthesis may counter the loss of reaeration capacity due to turbulence and mixing, while the deposition of organic matter as velocity decreases may cause an additional BOD exertion. In a stratified impoundment, productivity of the epilimnion also has a strong influence on water quality conditions in the hypolimnion. If nutrient loadings and other factors are conducive to eutrophication, the cycling of dead algae, weeds and other organic matter to hypolimnetic waters may aggravate dissolved oxygen deficiencies and water quality deterioration.

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[16] Krenkel, P. A., E. L. Thackston, and F. L. Parker, "Impoundment Effect on Waste Assimilation," Journal of the Sanitary Engineering Division, ASCE, Vol. 95, No. SA1, pp. 37-64 (February 1967).

[17] Vanderhoof, R. A., "Changes in Waste Assimilative Capacity Resulting from Streamflow Regulation," in Symposium on Streamflow Regulation for Quality Control, Public Health Service Service Publication No. 999-WP-30, 1065, p. 130.

The possibility of density flows in a stratified impoundment should also be assessed in considering assimilative capacity changes. If existing summer water temperatures in inflowing streams are likely to be considerably lower than expected epilimnion temperatures, the water may move through an impoundment in a layer below the epilimnion where reaeration is minimal. These temperature differences might be due to cold releases from an upstream impoundment or particular watershed characteristics. High-gradient, well shaded streams, for example, may be significantly cooler than others wit' flat gradients flowing through unforested areas. Any oxygen-demanding waste entering the hypolimnion with inflowing water will, in this case, probably contribute to lowering hypolimnetic water quality.

Evaporation. Another consideration relevant to water quality prediction or estimation is evaporation, which may be very significant in certain geographical areas. Fairly accurate estimates of water losses by evaporation can be made through studies of pan evaporation and the reservoir heat budget. The problem may reach major proportions in arid or semi-arid regions in the West and Middle West. As an example of the magnitude of water that can be involved, evaporation and seepage losses from Cheney Reservoir in Kansas represent about 42 percent of river inflow and local precipitation.[18] Such losses will result in increased concentrations of dissolved solids in the reservoir and downstream, as well as proportional decreases in streamflow.

Impacts on Fisheries and Other Biota. Ecological impacts in the area of impoundment result both from the initial filling and loss of terrestrial habitat and from the continued existence of an artificial lake. In quantifying the short- and long-term implications of flooding an area of land, the general concepts of magnitude, quality and relative supply, and uniqueness of the resource as described in Section IV.A.2 should be used. The relationship of different land uses and habitat types to the regional resource base must be logically described if an accurate estimate of impact is to be made. Likewise, the values of an impoundment's ecological and recreational resources should not be quantified in an isolated analysis; rather, comparison with availability in the region is again essential.

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[18] Ward, J. C., and S. Karaki, "Evaluation of Effect of Impoundment on Water Quality in Cheney Reservoir," Research Report No. 25, for the Bureau of Reclamation, Washington, U. S. Government Printing Office, 1971, p. 45.

The biological characteristics of an impoundment will be determined largely by conditions discussed previously in other sections, such as: (1) impoundment water quality as affected by morphometry, inflowing water quality, site characteristics, and project operational features, and (2) ecological character of unimpounded stream, including species composition and diversity In addition, introduced or stocked species of fish will alter impoundment ecology.

The productivity of an artificial impoundment with respect to fisheries will be affected by many factors, but in general will closely parallel changes in trophic status, beginning when the reservoir is filled. Almost all impoundments undergo an initial surge in productivity for a few years after dam closure, and growth of game fish populations may be rapid. It is important that proposed management of the impoundment fishery be delineated in the EIS. In the absence of conscious management and/or insufficient harvest by anglers, the full value of the fishery as a recreational resource may not be realized. In many parts of the country, there is an overabundant supply of lake-type warmwater fishing opportunities and an undersupply of coldwater fishing. This situation may prohibit an impoundment from receiving the high degree of fishing pressure normally required to maintain and improve reservoir warmwater fisheries.

In order to establish and keep a coldwater fishery in an impoundment, two primary criteria must be met: adequate temperature and adequate dissolved oxygen. As a general rule, trout need water temperatures throughout the summer of less than 65°F, or 70°F at the most, and dissolved oxygen concentrations about 5 or 6 mg/l to survive and grow adequately. These conditions will probably not be met in portions of the hypolimnia of many thermally stratified impoundments, especially if nutrient levels either from upstream sources or reservoir bottom land are expected to be high. The feasibility of establishing a trout fishery in a stratified reservoir is best evaluated after impoundment when detailed water quality surveys can be taken in the lake. Thus, any benefits assigned to trout fishing in an impoundment should be analyzed carefully with regard to suitable temperature and oxygen requirements.

Area-volume curves for an impoundment, comparable to those shown on Figures IV-1 and IV-2, may be of some use in estimating impoundment characteristics in relation to possible impacts on aquatic biota. The approximate depth of the thermocline at a proposed impoundment may be predicted or estimated in an EIS. If not, examination of thermal stratification data for nearby lakes or reservoirs of similar size may give a rough approximation of conditions to expect. Then, the area-volume curve can be used to estimate the volume of water stored in the hypolimnion of the proposed impoundment. This may define, in effect, the portion of the impoundment that will be unusable by fish and other organisms if conditions of hypolimnetic oxygen deficiency are expected. Continuous releases of cold water from an impoundment with a relatively small hypolimnetic volume may exhaust the cold water supply at some time in the summer. As warmer waters sink from above, outlet water temperatures may rise significantly. This occurrence would obviously jeopardize maintenance of a coldwater fishery in downstream sections.

The shift from a stream ecosystem to a lake environment will be accompanied by important changes in the relative abundance of aquatic organisms. Eutrophication, water level fluctuations, and alteration of temperature, velocity, depth, bottom characteristics, and water quality all influence the resulting composition and diversity of species in an impoundment. Many biota have narrow or at least fairly well defined tolerances with respect to these conditions. Based on an inventory of species and populations in the stream segment, the reviewer should expect the EIS to state which species will be favored, decreased in abundance, and eliminated following impoundment. Experience at other reservoirs in the region may prove particularly valuable for assessing the probable decline or increase of various species. Finally, the importance of certain fish and other biota for recreation and other uses should be quantified in relation to the supply of the resource in the region.

B.2.c Downstream Impacts from Impoundment Operation

Downstream impacts are closely related to impoundment water quality, method of discharge and changes in flow regime caused by a project. (Impacts on water quality caused by land use changes are discussed separately in Section IV.A.) Downstream water quality will normally compare closely with the quality of impounded water at the level of the outlet. Obviously, discharges from near the surface would probably be well oxygenated, clear, and somewhat warmer than inflowing water, whereas, hypolimnetic releases would reflect the possibly poorer quality water stored there.

The magnitude and importance of ecological changes vary according to the purposes, site characteristics, size, and regional environmental setting of an impoundment thus necessitating a case-by-case evaluation. In general, however, flood control impoundments that do not include extended storage for other purposes have the least effect on downstream flows, with little or no regulation except during potential flood situations. Aquatic ecological impacts in downstream reaches will probably be minor unless water temperatures are changed markedly. For larger multipurpose projects, operational patterns necessarily are more complex and discharges may deviate substantially from natural conditions. Changes in physical and chemical water quality may further complicate analysis of ecological impacts. The likelihood of significant impacts on resident and anadromous species (if present), productivity, and aquatic habitats increases as temperature, flow rates, sediment load and water quality depart further from natural unimpounded conditions.

Changes in Hydrographic Regime

Impacts on Water Quality Management. The general pattern of flow regulation by an impoundment will be largely determined by the hydrology of the basin, project uses and allocation of storage to these uses. Artificial manipulation of streamflow may follow daily cycles, as at peaking power dams, temporary or seasonal shifts caused by flood control and flow augmentation, and a general decrease in discharge due to withdrawal uses of water and evaporation. Any of these may be superimposed at multipurpose projects. The reservoir operating policy and resulting flow modification will have a strong influence on the nature of other physical, water quality and biological impacts which occur downstream from the dam.[19] Quantitative estimates of the degree and timing of flow regulation at an impoundment are therefore important for comparing expected discharge patterns with preimpoundment flows and assessing possible impacts.

Since withdrawal uses of water at an impoundment project, as well as evaporation, will decrease streamflow below the dam, the following several aspects of these uses should be quantified in the EIS:

(1) The volume of impoundment storage allocated to withdrawal uses and corresponding reservoir elevations.
(2) The maximum annual yield from the allocated storage for different annual inflows (wet, normal and dry years).
(3) Minimum project release requirements during withdrawal.
(4) Restrictions on rate of pool drawdown.
(5) Seasonal requirements of withdrawal uses.
(6) Projected water demands and use of stored water in impoundment.

Items (1) and (2) above define the decrease in annual streamflow, neglecting evaporation and other losses, that could be expected from maximum water supply withdrawals under various hydrologic conditions.

Minimum release requirements and regulation of the rate of pool drawdown, (3) and (4), may often be spelled out in a contract between the government and the water supply user and have an influence on the amount of water that can be withdrawn from the impoundment. At a flood control/water supply project, discharge to the downstream channel may be strongly influenced by regulation which takes place during withdrawal. At some impoundments, the intake or diversion works may be completely separate from the outlet structures that control flow downstream from the dam, and other water uses may govern reservoir releases.

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[19] Ortolano, L., D. J. Ringel, and J. R. Jones, "Environmental Impacts Associated With Reservoir Projects," in Ortolano, L., (ed.), Analyzing the Environmental Impacts of Water Projects," U.S. Army Engineer Institute for Water Resources, NTIS AD-766 286 (March 1973).

In water supply contracts between the Corps of Engineers and water users the government may reserve "the right to maintain at all times a minimum downstream release of ___ cubic feet per second..."[20]

Any special seasonal flow requirements should be fully described in the EIS. The minimum flow may be set at a level exceeding the design flow for downstream waste treatment plants, but its sustained occurrence during periods when natural flow is substantially higher may interfere with water quality management. For example, maximum daily pollutant loads for Water Quality segments are to include provision for seasonal variation,[21] and might have to be adjusted accordingly if water withdrawals frequently and regularly interrupted normal downstream flows. Similarly, thermal load allocations established under the state's Section 303(e) basin planning program, as well as individual NPDES permits, might have to be revised in light of significantly altered discharge and temperature conditions.

Hydroelectric plants used to generate peak power usually cause very large fluctuations in downstream flow, both diurnally and between weekdays and weekends. Cyclic discharges related to peaking operation may reach several thousand cubic feet per second during the daytime period of high power demand while flows at night or other off-peak periods may be restricted essentially to leakage and local inflow. It has been shown that aeration capacity lost at high discharge is greater than that gained at low flow;[22] therefore, release of poorly aerated hypolimnetic water may cause a significant reduction in downstream assimilative capacity even with high flows. The abrupt changes in flow over a 24-hour period caused by power generation may have other effects on water quality. Suspended organic matter entering the stream at the waste discharge points may settle, at a water velocity of less than 0.183 m/sec (0.6 ft/sec), to the stream bottom during off-peak hours and be resuspended when the velocity reaches 0.305 to 0.458 m/sec (1.0 to 1.5 ft/sec).[23] The suspension of sludge deposits in the vicinity of a sewage outfall due to flow increases may result in a further decrease in DO. In addition, extreme variations in flow may cause severe scouring and bank erosion in downstream sections.

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[20] Virginia Polytechnic Institute, "Legal Aspects of Water Storage for Flow Augmentation," Appendix II, typical Corps of Engineers Contract, prepared for Water Quality Office, EPA, Water Pollution Control Research Series Report 16090 FPW 03/70, August 1970, pp. 195-200.

[21] 40 CFR Part 131.304.

[22] Krenkel, Thackston, and Parker, op. cit., p. 52.

Federal law relating to low-flow augmentation has undergone a number of revisions, the most recent and important of which is contained in Section 102(b) of the FWPCA Amendments of 1972. The new law and attendant implementing policy require that EPA determine the value of flow augmentation for water quality control. This may take place at both the preauthorization phase and post-authorization study stage as well as during review. EPA policy and guidelines regarding low-flow augmentation, and any earlier EPA recommendations made during project planning are relevant inputs to the EIS review process. (Projects for which funds to initiate construction were appropriated prior to 18 October 1972 are not subject to EPA's determinations regarding water quality control storage.) Predicted impoundment water quality and the timing and methods of discharge are especially important in assessing low-flow augmentation. The quality of reservoir outflow will be a major determinant of the volume of storage needed for a certain incremental improvement of stream quality.

Through the issuance of NPDES permits that specify maximum daily pollutant loadings in terms of weight and in some cases concentration or discharge as well, the states now have control over variable and increased waste discharges which if used effectively could be an alternative to low-flow augmentation. Regulation of downstream uses of the extra dilution water may depend on applicable water rights, for example, the riparian or prior appropriation doctrines. Further information on state water policies and special situations relating to flow augmentation may be obtained from the report, "Legal Aspects of Water Storage for Flow Augmentation,"[24] although it is not reflective of new requirements under the FWPCA Amendments of 1972. It should be noted that storage required to offset mineral water quality deterioration primarily attributable to irrigation must be allocated to that purpose rather than water quality control.[25]

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[23] Velz, C. J., "Significance of Organic Sludge Deposits," in Oxygen Relationships in Streams, op. cit.

The EIS should present sufficient information on anticipated hydrographic modification at an impoundment project so that probable effects on water quality management can be identified. If the magnitude and frequency of low flows are altered by the impoundment or if greater variability of discharge results, water quality may suffer. Since treatment plants are typically designed for waste flows that may occur 15 to 20 years in the future, the reviewer must also be able to determine what impoundment-induced alterations in water quantity and quality may occur within this longer time frame. Possibilities might be the siting of a thermal-electric power plant near the reservoir to obtain cooling water, or phased increases in water supply withdrawals or utilization of irrigation storage over a number of years.

Impacts on Stream Ecology. Many of the ecological impacts associated with alteration of a stream's flow pattern are subtle and not easily quantified. Also, because of the interrelationships of discharge with physical and chemical water quality, ecological changes below a dam may often occur due to a combination of these factors. However, effects on fish spawning, benthic organisms, riparian and stream vegetation and other biota have been related directly or indirectly to flow regime modifications. The difficulties in predicting the magnitude of such impacts become evident upon examining relevant published materials. Therefore, the guidelines presented herein are oriented primarily to identification of probable impacts downstream from a proposed impoundment, supplemented by quantitative information and techniques as available.

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[24] Virginia Polytechnic Institute, op. cit.

[25] U.S. Environmental Protection Agency, "Policy on Storage and Releases for Water Quality Control in Reservoirs Planned by Federal Agencies," 16 January 1975.

As a general rule, greater downstream ecological changes should be expected with increased deviations from the preimpoundment flow regime since the aquatic ecosystem has adjusted to natural seasonal variations in discharge. Ideally, the determination of discharge recommendations should be based on quantification of the water flow needs of the species inhabiting reaches below a dam. In practice, however, these needs may conflict with the attainment of maximum economic benefits from a project so that a compromise must be reached. An assessment of downstream ecological impacts should begin by noting the major features of the proposed flow regulation schedule, including the effect of the project on natural high and low flows and on total annual discharge. In certain instances, such as at hydroelectric peaking power plants, diurnal and weekly variations may be substantial. An inventory of downstream fish species and brief description of other water resource projects contributing to flow regime changes in downstream sections are also important for evaluation of ecological changes.

Ecological impacts caused by reduction of flood peaks below an impoundment project may relate to both flood plain areas and the stream itself as well as to the estuary in certain cases. Except in the event of an unusually large flood, most flood control projects are designed to keep flows below a safe channel capacity, above which downstream damages will begin to be incurred. In some parts of the country, allowable discharges may be higher in the non-growing season when agricultural crops are not threatened by flooding. An impoundment may provide protection to industries, residences, commercial establishments, roads, farmland and other development in the flood plain. However, undeveloped natural flood plains may exhibit unique associations of vegetation that are tolerant of recurrent inundation during periods of high runoff. These semi-wetland areas often drain slowly after recession of flood peaks, with large amounts of water remaining in standing pools and infiltrating into the ground.

In most cases, reduction of streamflow due to impoundment will adversely affect downstream ecology while flow augmentation may have certain benefits. Frequently, decreases in discharge result in increased stream temperatures, which may be critical at certain times of the year. The flow and thermal requirements of salmon and other anadromous species have received the most intensive study, but the general observations may apply also to resident or migratory freshwater fish as well. For salmon, low water levels during migration may cause significant delay in reaching spawning grounds because of either low water velocities or exposure of obstructions or barriers in the stream channel.[26] Streamflows during the incubation period following spawning must be sufficient to prevent deposition of sediment on the eggs, wash away waste products, and prevent dehydration. Fraser[27] describes situations where curtailing flows may result in riparian vegetation encroachment on spawning areas for salmon. Many fish, most notably trout, occupy and defend certain territories, the size of which decreases with increasing velocity. It is probable, then, that sustained streamflow reductions may in fact reduce the carrying capacity of a regulated river.

The EIS should provide data on both preimpoundment and postimpoundment low flow events (monthly, weekly, daily). Comparisons of these data will help reveal the extent of the hydrologic modification and its effect on the downstream communities. If the impoundment is in an arid area and is fed by one or more ephemeral streams, water quality conditions at low flow must be estimated. Evaporation may be an important consideration in these cases.

Changes in Thermal Regime

Whereas the major focus of state water quality standards and certain EPA programs is on thermal pollution and prevention of unacceptable water temperature increases, an impoundment has the potential to significantly raise *or* lower downstream water temperatures. The direction, magnitude and timing of such thermal regime changes determine in part the biological impacts that may occur below a dam. Quantification or estimation of these impacts is dependent on (1) baseline data describing the existing temperature regime and aquatic biota (species and composition), (2) expected temperature patterns under impounded conditions, and (3) definition of downstream priorities for fisheries and stream uses and related temperature requirements. The following paragraphs explain the importance and use of this information in evaluating temperature-related ecological impacts, so that the adequacy of the EIS discussion can be judged or, if necessary, probable impacts estimated.

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[26] Gordon, R. N., "Fisheries Problems Associated with Hydroelectric Power Development," *Canadian Fish Culturist*, 35:17-36 (October 1965).

[27] Fraser, J. C., "Regulated Discharge and the Stream Environment," *River Ecology and Man*, R. T. Oglesby, *et al.*, editors, New York: Academic Press, 1972, pp. 263-286.

The existing temperature pattern in and below the stream reach to be impounded may be relatively free from human influence or may be modified by upstream thermal effluent discharges, cold-water releases from an upstream reservoir, or land use practices, such as clearing of trees along the banks, that contribute to warming of the stream. Fish, insects and other biota inhabiting the stream are reflective of the particular thermal regime because reproduction, growth and survival of different species often depend on water temperature.

As a minimum, the EIS should present data on general seasonal variations of preimpoundment stream temperatures, such as monthly average values, along with approximate summer maxima. This information is valuable for purposes of comparison with predicted temperature patterns and estimation of fish spawning periods and possible temporal shifts. An inventory of fish species in the vicinity of the project site is valuable for characterizing the stream habitat. Important categories are: (a) cold- and warmwater game fish, whether native, stocked, or native and supplemented by stocking, (b) nongame fish (rough and forage species), (c) anadromous and catadromous species, (d) rare and endangered species. The state fish and game agency or the U.S. Fish and Wildlife Service can probably furnish a complete, or nearly complete, species list if the EIS contains insufficient information (for example, only species sought by anglers may be mentioned). The EIS should also include information on the thermal requirements of these organisms. (See Table IV-5).

Prediction of discharge water temperatures for various inflow, storage and discharge conditions at a proposed impoundment is requisite to identification of downstream ecological impacts. The process may be relatively straightforward for single-purpose projects or highly complicated by such factors as variable discharge elevation, thermally induced density currents, depth of thermocline, thickness of the withdrawal layer, and thermal discharges to the impoundment or river upstream from the reservoir.

If discharges are to be made from the surface layer, using either an overflow weir or selective withdrawal gates at different elevations according to the pool level, downstream temperature will correspond closely to that of the reservoir surface. The pool surface area exposed to solar heating and flow-through time in the upper layer will both affect discharge temperatures, which during the summer and early autumn may be significantly higher than inflow temperature. If the normal summer pool is not expected to stratify, the location of reservoir outlets near the surface or near the bottom is likely to be unimportant with respect to discharge water temperature since such a pool would be nearly isothermal. Major changes in the downstream thermal regime will accompany continuous or intermittent hypolimnetic discharges from deep, thermally stratified impoundments. Temperature predictions under these conditions are most difficult, especially if water is withdrawn from two different layers simultaneously as might be done to improve water quality of the releases. For purposes of estimating ecological impacts, the temperature variations in the period from late spring through early or mid-autumn are usually most critical; however, the effects of temperature variations on the ecological community at other times of the year should not be overlooked.

For impoundment projects whose operation may substantially alter, or provide a high degree of control over, downstream water temperatures, knowledge of thermal constraints for various stream uses is essential. Possibly conflicting thermal requirements should be addressed and, if there is consensus among agencies responsible for the affected resources, thermal priorities should be established in the EIS. Most of the questions concerning the effects of downstream temperature changes would involve the desirability of releasing cold hypolimnetic water during the stratified period. Specific issues that may arise include: the preservation of an existing or creation of a new coldwater fishery, maintenance of existing warmwater species composition, and releases of cold water to benefit downstream withdrawal uses for water supply or cooling.

Low-level releases from an impoundment may cause a significant reduction in downstream water temperatures from spring through early summer or later. In the winter, a warming effect may be evident when the deepest water will have a temperature near 4°C (39°F) as opposed to inflow temperatures just above freezing. This altered thermal regime has been implicated in the elimination or reduction of benthic fauna as well as certain fish species for varying distances downstream from reservoirs with hypolimnetic outlets. Many insect species, such as mayflies, which are important food organisms for fish and other animals, have life cycles dependent on strict temperature requirements. Lehmkuhl[28] observed a marked decrease in the number of species and abundance of macroinvertebrates for a distance of 70 miles downstream from a reservoir on the South Saskatchewan River. He attributed the decline to hypolimnetic discharges from the dam, since the warm water requirement for hatching and growth of the species involved was not met. Most aquatic invertebrates have temperature-dependent seasonal life cycles and may not be able to tolerate major modifications of a river's thermal regime.

Because macroinvertebrates form an important link between primary producers (phytoplankton) and fish in the food chain, their reduction may adversely affect productivity of the stream fishery. However, prediction of this relationship is complicated by the influence of temperature on gross productivity and chemical reactions, and the fact that nutrient inputs to the downstream ecosystem may change due to impoundment. Hynes' book *The Ecology of Running Waters*[29] offers some information on temperature requirements and seasonal life cycles of various aquatic insects if a general estimation of changes in species composition is needed.

The predicted thermal regime below an impoundment will directly affect the type and perhaps the quality of the stream fishery that can be maintained. If hypolimnetic discharges are planned, estimates should be made of both the discharge temperature variation during the stratified period and the temperature "recovery" with distance below the dam. Generally, temperatures could be expected to rise less rapidly in deep and/or well shaded streams. The cooler water temperatures in the affected zone may delay or prevent spawning of warmwater fish species and enhance conditions for trout or other coldwater species. Changes in fish species composition due to impoundment can be quite dramatic: In a preimpoundment survey of Beaver Reservoir on the White River, Arkansas, 72 species and 5 hybrid combinations were reported; whereas subsequent to impoundment only 29 species were collected in the tailwater area below the dam.[30] Cold tailwater temperatures may also inhibit reproduction of warmwater species without causing their complete disappearance. Certain trade-offs may have to be made with respect to a postimpoundment downstream fishery. In a survey of 32 projects in southern states, 43 percent of the total tailwater miles were reported to be marginal waters which provided little or no fishing.[31] The views of the Fish and Wildlife Service, which should be summarized in the EIS, should aid in evaluating the effects of impoundment on the downstream fishery. Replacement of a productive, heavily fished stream, whether warmwater or coldwater, with a marginal or a "put-and-take" trout fishery that must be maintained by stocking should be considered an adverse ecological impact, even though recreational use may be increased considerably.

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[28] Lehmkuhl, D. M., "Change in Thermal Regime as a Cause of Reduction of Benthic Fauna Downstream of a Reservoir," *J. Fish. Research Bd. Canada*, Vol. 29, No. 9 (Sept. 1972), p. 1331.

[29] Hynes, H. B. N., The *Ecology of Running Waters*, Univ. Toronto Press, Toronto, Ont., 555 pp. (1970).

In the absence of significant inputs of thermal effluents downstream from an impoundment, the release of warmer epilimnetic water is unlikely to have measurable adverse effect on an existing warmwater fishery below a dam. However, this mode of operation would undoubtedly create temperature conditions unsuitable for the survival and reproduction of trout and other coldwater species if they were present prior to dam construction.

The major changes in flow regime, water temperature, and dissolved oxygen that may occur downstream from stratified impoundments often overshadow the effects of other water quality parameters. Two effects which may be extremely harmful to downstream biota, but which occur only in special cases, are supersaturation of dissolved gases and accumulation and release of hydrogen sulfide. Nitrogen supersaturation is a major problem at high dams in the Northwest and West where heavy spillway discharges are encountered. The phenomenon causes gas bubble disease and often mortality in affected fish. Further biological information is contained in "Proposed Criteria for Water Quality," Volume I Quantitative data and general discussions of the problem can be found in articles by Beininger and Ebel[32] and Boyer.[33]

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[30] Hoffman, C. E. and R. V. Kilambi, "Environmental Changes Produced by Cold-Water Outlets from Three Arkansas Reservoirs," Water Resources Research Center Publication No. 5, University of Arkansas, Fayetteville, Arkansas, 1971.

[31] Pfitzer, D. W., "Evaluation of Tailwater Fishery Resources Resulting from High Dams," in C. E. Lane, Jr. (ed.), Reservoir Fishery Resources Symposium, Southern Division, American Fisheries Society, Univ. of Georgia, 1967, p. 485.

Hydrogen sulfide is toxic to fish at low concentrations (see Table IV-2). In a few instances fish kills have occurred downstream from dams releasing anaerobic water containing hydrogen sulfide. It is likely that the problem would not persist for a large distance downstream if it were to occur, because mixing and aeration would disperse the gas to the atmosphere.

Reduction of sediment load combined with release of possibly nutrient-rich water from the hypolimnion may stimulate eutrophication downstream. Wright observed that cities withdrawing water from rivers downstream of large impoundments experienced taste and odor problems due to algae growth, necessitating additional water treatment in some cases.[34] Whether nutrient increases have resulted in better productivity of downstream fisheries is uncertain. Since temperature, oxygen and flow may all vary considerably, it is difficult to separate out effects of any one factor.

Ecological impacts due to combinations of the changes discussed above may be evident long distances downstream from an impoundment. These far-reaching impacts often occur cumulatively in basins whose water resources are highly developed for power, flood control, irrigation and water supply. Effects on estuarine ecosystems and agricultural productivity in deltas, generally linked to major flow regime and sediment-load changes, are discussed in the report *Analyzing the Environmental Impacts of Water Projects*[35] and in the publications referenced therein.

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[32] Beininger, K. T., and W. J. Ebel, "Effects of John Day Dam on Dissolved Nitrogen Concentrations and Salmon in the Columbia River, 1968," Trans. American Fisheries Society, Vol. 99, No. 4, pp. 664-671 (October 1970).

[33] Boyer, P. B., "Gas Supersaturation Problem in the Columbia River," in Age of Changing Priorities for Land and Water, Proceedings of the ASCE Irrigation Division Specialty Conference, Spokane, Washington, September 26-28, 1972, pp. 205-209.

[34] Wright, J. C., "Effect of Impoundments on Productivity, Water Chemistry and Heat Budgets of Rivers," in C. E. Lane, Jr. (ed.), op. cit., p. 192.

B.3 Assessment of Impacts

EPA's basic policy regarding the water related impacts of impoundments is as follows:

> Flow regulation practices that result in lower than natural low flows (i.e., those which would occur in the absence of the impoundment) or release water of less than preimpoundment quality (e.g., zero dissolved oxygen) are considered to be in violation of the anti-degradation clause of the water quality standards. During periods when natural flows equal to or less than the flow values used to design waste treatment facilities located downstream from the site of a proposed impoundment would occur, the rate of discharge past the dam should be at least equal to the rate of inflow above the dam, whether or not water quality storage is provided.[36]

An assessment of impacts should therefore include both: (1) relating identified and quantified impacts to appropriate environmental standards and criteria, and (2) determination of the need, applicability and effectiveness of alternative mitigative techniques as well as alternatives to the proposed project (scope, location, or alternative means of meeting water resource objectives), which may or may not be addressed in the EIS.

B.3.a Impacts During Construction

Water pollution from construction activities, although usually of short duration, may nevertheless be an important source of environmental impacts. Deposition of sediments on the stream bed may severely reduce populations of bottom dwelling organisms and eliminate habitat for species that require clean gravel or rubble for spawning. Aesthetic and recreational values of a stream may also be adversely affected by turbidity during construction. Pesticide residuals resulting from application in proper dosages will probably not directly affect aquatic biota; however, some such chemicals are highly toxic, nonbiodegradable, and readily concentrated by plants and animals and may have cumulative impacts. Accidental spills of pesticides as well as oil and other chemicals pose the possibility of fish kills and other environmental damage at impoundment construction sites. Careful handling and use of hazardous materials are necessary to minimize water quality and ecological impacts.

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[35] Ortolano, Ringel, and Jones, *op. cit.*, p. 5-54.

[36] U.S. EPA, "Guidelines of the Environmental Protection Agency Regarding Storage and Releases for Water Quality Control in Reservoirs Planned by Federal Agencies," 10 January 1975.

Construction-related impacts on water quality cannot be quantified very easily, even though it is known that some pollution will occur during the construction period. Therefore, the purpose of assessing water pollution from construction should be to assure the use of all feasible methods for reducing or avoiding pollution and maintaining water quality standards. EPA's proposed water quality criteria specify that for freshwater aquatic life, the maximum acceptable total concentration of suspended solids is 80 mg/l, depending on the level of protection desired. The basic rationale for this criterion is that waters containing suspended solids concentrations in excess of 80 mg/l are unlikely to support good freshwater fisheries. Water quality standards of some states specify numerical criteria for turbidity as well as general guidelines relating to the effects of suspended matter in watercourses. For example, Vermont's water quality standards require turbidity levels not to exceed 10 Jackson Turbidity Units (JTU) for coldwater streams and oligotrophic lakes supporting trout, or 25 JTU in warm waters "as a result of any discharge or activity, except as may result from natural conditions or as may be permitted in accord with the conditions of a temporary pollution permit or order of the Secretary."[37] The rules further state that Class B waters be free of pollutants that (a) affect the composition of bottom fauna, (b) affect the physicial or chemical nature of the bottom and (c) interfere with the propagation of fish.

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[37] State of Vermont, Agency of Environmental Conservation, Water Resources Board, "Regulations Governing Water Classification and Quality Control," adopted in accordance with 10 V.S.A. 905(a) (12), 20 December 1973.

It is important that the review be coordinated with appropriate state agencies that may have specific recommendations or requirements for environmental protection during construction. During construction of Martis Creek Dam, for example, California's Regional Water Quality Control Board established requirements which limited the increase in turbidity in the creek, an important trout stream, to not more than 10 JTU during any consecutive four-hour period, nor more than 20 JTU during any one-hour period, nor more than 100 JTU at any one time.[38] The requirements were incorporated into construction specifications for the project.

Downstream uses may contribute largely to determination of acceptable turbidities and concentrations of other pollutants originating at a construction site. EPA's "Proposed Criteria for Water Quality" suggest that clarity for bathing and swimming waters be such that a Secchi disc is visible at a minimum depth of 4 feet, which corresponds to a turbidity of about 10 JTU.[39] In some instances, then, the protection of recreational and aesthetic values may necessitate even stricter controls than are required for preserving fish and wildlife. Water supplies withdrawn from the river below an impoundment construction site may also be adversely affected by higher than normal turbidity, perhaps to the extent that additional expenditures or process modifications for treatment are required.

In construction of a dam, some excavation, earthmoving, and other activities necessarily occur in the stream or immediately adjacent to it. A special set of criteria may be desirable for application during construction. The criteria should be designed for reasonable protection of the most water quality-sensitive stream use, with perhaps some degree of flexibility, as in the turbidity limits for construction of Martis Creek Dam mentioned above. For protection of water quality in the construction period, activity scheduling and proper location of access and haul roads, as well as land treatment and process water treatment systems should be considered. Depending on the particular topographic conditions, any of the following methods of erosion control might apply: (1) minimize soil exposure, (2) control runoff, (3) shield soil, and (4) bind soil. These are discussed briefly below, with supplemental information available in "Processes, Procedures, and Methods to Control Pollution Resulting from All Construction Activity."[40]

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[38] Sciandrone, J. C., "Environmental Protection at California Dam, *Civil Engineering*, Vol. 44, No. 3, March 1974, p. 80.

[39] Katzer, M. F., "Control of Turbidity at Construction Sites," in *Economical Construction of Concrete Dams*, Proceedings of the Engineering Foundation Conference, May 14-18, 1972 (ASCE, New York), p. 356.

Soil Exposure. Minimizing the exposure of disturbed soils, particularly during seasons of the year when high intensity rains may be expected, can be best accomplished by careful timing. Excavation and earthmoving activities should be scheduled to minimize total exposure at any given time and, as earthmoving operations are completed, some of the following methods might be instituted to reduce erosion.

Control Runoff. Minimizing the quantity of water before it can run over an exposed slope by using terraces, ditches and dikes on upper slope areas is another control method. Rain falling directly onto the surface may be handled by scarifying slopes to reduce the flow velocity and inducing infiltration, thereby reducing erosion. This may be accomplished with shallow grooves following contours of the slope.

Shield Soil. Numerous types of ground cover, both vegetative and nonvegetative, may be used to protect exposed slopes. Nonvegetative mulches include straw, hay, wood chips, stone and gravel. The erosion control effectiveness of these mulches at various application rates has been evaluated under closely controlled experimental conditions; some results are summarized in Table IV-1. In these experiments, stone, gravel and wood chips were tested because of their general availability at construction sites. The table may be used generally to determine whether specifications relating to slope protection are stringent enough to avoid severe erosion. Due to increased restrictions on open burning, small trees, brush, and limbs from clearing of impoundment areas may provide a large source of wood chips for use as mulch material. The greatest shortcoming

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[40] U.S. EPA, Office of Air and Water Programs, "Processes, Procedures and Methods to Control Pollution Resulting from All Construction Activity," Washington, D.C., October 1973 (EPA 430/9-73-007).

Table IV-1: Soil Losses from 5 Inches of Simulated Rain on Denuded Slopes for Various Types and Rates of Mulch

Mulch	Application Rate (tons/acre)	Soil Loss (tons/acre)	Percent Reduction in Soil Loss
None*	--	39.6	--
Portland cement	--	32.7	17
Wood chips*	2	27.1	32
Crushed stone*	15	25.6	35
Gravel	70	14.7	63
Straw	2.3	12.1	69
Crushed stone	60	11.4	71
Wood chips	4	8.5	79
Wood chips*	7	5.5	86
Crushed stone*	135	3.5	91
Crushed stone*	240 & 375	<2	>95
Wood chips*	14 & 25	<2	>95

Rain intensity, 2.5 inches per hour; slope length, 35 feet; slope steepness, 20 percent; soil, calcareous till beneath Wingate silt loam.
*Based on one replication; others are averages for two replications.

Source: Meyer, L. D., C. B. Johnson, and G. R. Foster, "Stone and Woodchip Mulches for Erosion Control on Construction Sites," Journal of Soil and Water Conservation, Vol. 27, No. 6, November-December 1972, p. 267.

of nonvegetative mulches is the possibility of rilling. Once drainage on a mulched slope becomes established in small rills rather than through the mulch material, mulching loses much of its effectiveness.

Fine mesh netting stone riprap, and impermeable materials such as tarpaulins and plastic mats, may also be used for temporary stabilization of relatively small areas. The faces of earth dams are commonly riprapped with stone since maintenance is reduced considerably in comparison with sodded embankments.

Bind Soil. Vegetation such as grasses, shrubs, and other ground cover is often used to bind the soil and minimize water erosion. It is important that the vegetation be tolerant of the adverse conditions expected at the site (drought, sun, shade, soil nutrients, etc.). During construction periods, fast-growing annual grasses may be desirable alone or in a mixture with longer-lived grasses and/or mulches to provide more permanent control. Chemical binders, usually in liquid form, may be sprayed over exposed slopes or mixed with mulches to aid in reducing soil loss. However, due caution should be exercised when using potentially toxic or otherwise polluting chemicals to avoid contamination of surface or groundwater in the impoundment area.

Sediment control techniques may be necessary at an impoundment site in addition to the erosion control procedures described above. Vegetative controls may be used to detain or filter overland runoff before sediment enters waterways. Provision for natural or planted vegetative buffer strips between borrow areas, haul roads or other areas where soil is exposed and watercourses at the site may aid in minimizing turbidity increases.

In many cases, however, more elaborate controls are necessary, particularly where waste streams may be amenable to clarification by physical and chemical treatment. Temporary holding basins that allow larger particles to settle out from highly turbid waters may be constructed at low points in the impoundment area. Turbidity control plants have been used at impoundment sites to treat aggregate wash water, water that collects around diversion tunnels and other structures, and other water containing high concentrations of suspended solids. Chemical flocculants are often used to aid in removing fine particles. These chemicals should not be toxic to fish, wildlife or vegetation and adequate inspection should be required to insure application in proper and safe dosages. If not specified in the EIS, these or other techniques should be recommended for all polluted water that can readily be collected and treated.

B.3.b Impacts Due to Creation of Artificial Lake and Impoundment Operation

Based on EPA and state antidegradation policies and the guidelines in previous sections, it should be possible to assess water quality and ecological impacts at impoundments of differing sizes, site characteristics, purposes, and operational features. Table IV-2 summarizes water quality criteria for various constituents that may be affected by an impoundment. Individual states may have EPA-approved water quality standards prescribing different levels for these parameters, in which case state regulations would take precedence.

Table IV-2: Water Quality Criteria for Selected Constituents and Probable Effect of Impoundment*

Constituent	Water Use**	Criterion	Probable Effect of Impoundment
Iron	WS I	0.5 mg/l 5.0 mg/l for continuous irrigation	Increase in anaerobic or oxygen-deficient hypolimnion
Manganese	WS	0.3 mg/l	Increase in anaerobic or oxygen-deficient hypolimnion
Dissolved Oxygen	A WS	Variable[a] None prescribed, preferable near saturation	Depletion or deficiency in hypolimnion; with low-level outlets, may persist downstream
Sulfides (Hydrogen sulfide)	A	0.002 mg/l	May be present in anoxic hypolimnion
Dissolved Solids	I WS	500-1000 mg/l for sensitive crops None prescribed[b]	May increase due to evaporation, water diversion irrigation, or leaching
Sulfate	WS	250 mg/l	May increase due to evaporation, water diversion irrigation, or leaching
Chloride	WS	250 mg/l	May increase due to evaporation, water diversion irrigation, or leaching
Ammonia	WS	0.5 mg/l	May increase in anaerobic or oxygen-deficient hypolimnion, from bottom sediments
Odor	WS R	Essentially none Essentially none	May be problem in hypolimnion due to reduction products or in epilimnion due to algae
Clarity	R	4 feet Secchi disc visibility	May improve upon impoundment; however, excessive algae growth may reduce clarity
Microorganism Fecal coliform	I WS R	1000/100 ml 2000/100 ml (raw water 200/100 ml (waters used for swimming or water contact sports)	Normally significant reduction in impoundment; however, increases have been observed following drawdown after flood control operations

*Table source should be consulted for further background information

** I = Irrigation
A - Aquatic Life
WS = Public Water Supply Intake
R = Recreational Waters

[a] Varies with temperature and species
[b] Sulfate and chloride are most troublesome components

Source: U.S. Environmental Protection Agency, "Proposed Criteria for Water Quality," Volume I, Washington, D.C., October 1973.

Because the standards are designed to protect and enhance both aquatic life and stream water uses, they should be the primary basis for assessing aquatic ecological impacts as well.

Table IV-3 lists several important freshwater and anadromous fish and related thermal criteria for protection of the species during their spawning seasons. Although only a few of the listed species, along with many others, may be found in a given stream, their requirements are likely to govern the desirability and acceptability of thermal regime modifications caused by an impoundment project.

Table IV-3: Maximum Weekly Average Temperature for Spawning and Short-Term Maxima for Survival During the Spawning Season (Centigrade and Fahrenheit).*

Species	Optimum Spawning	Maximum	Spawning Season
Atlantic Salmon	5 (41)	18 (64)	Oct. - Dec.
Bigmouth Buffalo	17 (63)	--	Late Apr. into June
Black Crappie	16 (61)	--	Mar. - July
Bluegill	25 (77)	31 (88)	Apr., June - late Aug.
Brook Trout	9 (48)	22 (72)	Sept. - Nov.
Carp	20 (68)	31 (88)	Mar. - Aug.
Channel Catfish	27 (80)	34 (93)	Mid Apr. - late July
Coho Salmon	10 (50)	22 (72)	Fall
Emerald Shiner	23 (73)	29 (84)	May - Aug.
Freshwater Drum	21 (70)	--	Early May - late June
Lake Herring (Cisco)	4 (39)	18 (64)	Mid Nov. - mid Dec.
Largemouth Bass	21 (70)	30 (86)	April - June (North) Nov. - May (Florida)
Northern Pike	12 (54)	--	Feb. - June
Rainbow Trout	9 (48)	26.5 (78)	Nov. - Feb. Feb. - June
Sauger	10 (50)	--	Apr. - May
Smallmouth Bass	17 (63)	--	May - July (Ontario)
Smallmouth Buffalo	17 (63)	--	Late Mar. thru June
Sockeye Salmon	10 (50)	22 (72)	Fall
Striped Bass	18 (64)	--	Apr. - July
Threadfin Shad	18 (64)	--	Apr. - Aug.
White Bass	19 (66)	--	Apr. - July (North) Mar - May (Tennessee)
White Crappie	18 (64)	--	Mar. - July
White Sucker	10 (50)	24 (75)	Mar. - June
Yellow Perch	12 (54)	22 (72)	Mar. - June

*Based on 24-hour median lethal limit minus 2°C (3.6°F) and acclimation at the maximum weekly average temperature for optimum spawning for that month.

Source: U.S. EPA, "Proposed Criteria for Water Quality, Volume I," Washington, D.C., 1973, p. 165 and Appendix A.

By comparing thermal criteria for fish present at an impoundment site with expected temperature patterns, the reviewer can determine generally which species will be adversely or beneficially affected in downstream reaches. Table IV-3 presents information on a limited number of species which are considered important mainly because of their value for sport or commercial fishing. However, special circumstances, such as the existence of rare or endangered species or other locally important species, may introduce different temperature requirements.

Criteria of quality and uniqueness should be applied to ecological resources impacted by an impoundment project, whether rare or endangered species, anadromous fish, or special scenic, historic, aesthetic or geologic values. Mitigation measures cannot replace committed resources, but such alternatives as acquisition of wildlife ranges, wetlands and other lands, construction of fish by-pass facilities, or minimization of water quality impacts using techniques described below should receive full consideration and evaluation in an EIS.

The EIS must be responsive to water quality and ecological impacts that will result from impoundment. There should be a full evaluation of alternative measures for maintaining water quality as good as, or better than that existing prior to impoundment. In general, several techniques have been employed, including: (1) site preparation measures, (2) selective withdrawal outlets, (3) turbine aeration, (4) discharge aeration using Howell-Bunger valves, and (5) artificial destratification and hypolimnetic aeration. These are described in the following sections with enough detail to determine (a) their applicability at certain types of impoundments, (b) the water quality problems that can be ameliorated, and (c) drawbacks and limitations.

Site Preparation Measures

In the past, reservoir site preparation has varied from the removal of marketable timber only, to complete clearing and stripping of all organic soil, vegetation and debris. Neither extreme is usually optimal with respect to both future water quality protection and cost. The EIS should describe the degree of anticipated site preparation work as well as justification in terms of balancing water quality gains, recreational and aesthetic considerations against cost. The evaluation may be supported by field investigations or may be a result of general reconnaissance, consideration of proposed uses of the impoundment and professional judgment.

Removal of trees from an impoundment area is widely practiced, as much for aesthetic reasons and elimination of boating, fishing and debris accumulation hazards as for protection of impounded water quality. Cases often arise, however, where total clearing is not justifiable, feasible, or even desirable. Few reservoirs are cleared up to the gross pool (spillway) elevation, particularly if a portion of the total storage is allocated to flood control and is used only infrequently and for relatively short periods during high runoff. Many Corps of Engineers' reservoirs existing or being planned in the Northeast are operated so as to evacuate stored flood waters and recover flood control capacity as rapidly as possible following recession of a flood peak downstream, with no provision for extended storage for other purposes. Clearing elevation for such projects is often chosen on the basis of the storage required to regulate a flood of a certain frequency or recurrence interval, sometimes taken as five years.

Removal of stumps (grubbing), brush, herbaceous vegetation and topsoil may be included as part of reservoir site preparation activities, particularly if impoundment storage is to be used for public water supply. Such operations may involve considerable expense and oftentimes grubbing, if done at all, is restricted to higher elevations in the reservoir where drawdown is frequent. Removal of all stumps, roots and topsoil for a marginal 20 feet has been recommended.[41] Taste, odor, and other objectionable characteristics in water supplies may be avoided or lessened by the removal of organic materials.

The methods and scheduling of reservoir clearing, grubbing and other site preparation techniques should be assessed for resultant impacts on water and general environmental quality. Access roads through the basin should be planned to follow reservoir contours, both to minimize soil erosion and to allow piling and burning of brush in place, rather than dragging it toward the valley bottom.[42] Large depressions in the reservoir drawdown area should be self-draining to avoid ponding and stagnation of reservoir water; channels or ditches may thus have to be cut. Reservoir clearing should be scheduled for the dry season to minimize erosion of the unprotected reservoir during heavy rains. Reservoir clearing should be scheduled closely with work progress on the dam structure and ideally should be completed just prior to reservoir filling so that time of exposure is kept as short as possible. In addition to the increased threat of erosion, the regrowth of herbaceous cover in a long lag period between clearing and filling of the reservoir can contribute a significant additional oxygen demand in the first years of impoundment.[43]

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[41] Fair, G. M. and J. C. Geyer, Water Supply and Waste Water Disposal, John Wiley & Sons, New York (1954), p. 238.

Soil conditions in some parts of the reservoir may pose exceptional hazards to future water quality; for example, swamps, bogs or peaty soils with high organic contents are likely to impart characteristics unacceptable from the public water supply standpoint. Organic-rich soils may be stripped and removed from the reservoir, plowed under, or covered with a layer of mineral soil to prevent leaching of excessive iron, manganese, color and other undesirable constituents. The decision whether to do any of these things will be influenced by the amount of area exhibiting unfavorable soil conditions, the anticipated impairment of water quality for proposed water uses, the cost of the treatment, and the arrangements for water supply withdrawal and reservoir discharge.

Selective Withdrawal Outlets

In general, two principal water quality criteria, dissolved oxygen and temperature, are used to gauge the need for multilevel releases at an impoundment project.[44] Downstream requirements, uses of impounded water, and physical features of the project are also of concern in evaluating the applicability of selective withdrawal to a particular reservoir. Multilevel intake structures have been constructed at all types of single and multiple-purpose projects. A 1970 survey of 90 dams equipped with some kind of selective withdrawal devices is summarized in Table IV-4 to indicate the prevailing uses.

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[42] McCullough, C. A. and R. R. Nicklen, "Control of Water Pollution During Dam Construction," Journal of the Sanitary Engineering Division, ASCE, Vol. 97 No. SA1, pp. 81-89 (February 1971).

[43] Allen, E. J., "Taste and Odor Problems in New Reservoirs in Wooded Areas," Journal AWWA, 52: 1027-1032 (August 1960).

Table IV-4: Types of Impoundments Equipped with Selective Withdrawal

Primary Purpose(s)	Number of Projects
Single-purpose flood control	20
Single-purpose water supply	21
Single-purpose power	2
Water supply and flood control	21
Water supply and low-flow augmentation	6
Flood control and power	4
Other (includes navigation, irrigation and fish propagation in various combinations with the above)	16

Source: "Register of Selective Withdrawal Works in the United States," Task Committee on Outlet Works, Committee on Hydraulic Structures, R. E. Nece, Chairman, Journal of the Hydraulics Division, ASCE, Vol. 96, No. HY9, Proc. Paper 7533, September 1970, pp. 1841-1872.

Water supply is a primary impoundment purpose in 63 percent of the projects surveyed, and assuring provision of high quality water for municipal and industrial uses was likely an important factor in the decision to utilize selective withdrawal facilities.

If the EIS has satisfactorily demonstrated the probability of strong thermal stratification, eutrophication and associated water quality problems at a proposed impoundment, adverse downstream impacts from low-level discharges may occur. Multilevel outlets should be considered as one mitigation alternative worthy of investigation. Uses, advantages and limitations of selective withdrawal are discussed below.

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[44] U.S. Environmental Protection Agency, "The Control of Pollution from Hydrographic Modifications," Washington, D.C., 1973.

Withdrawal from Impoundment for Water Supply. Probably the most common use of selective withdrawal facilities is for controlling the temperature or chemical quality of water withdrawn from an impoundment for municipal and industrial water supply. Withdrawal points may vary from two intakes, one near the surface and one deeper in the reservoir, to numerous intakes evenly or unevenly spaced and capable of blending water from two or more elevations. Multilevel intakes can provide some flexibility and control over the quality of water introduced to a supply system. Their inclusion in a project may be simply a safety precaution in the event that quality problems are encountered after construction, and should be based on thermal and hydraulic modelling studies. Detailed water quality studies should also be undertaken. In either case, hydraulic and water quality changes caused by impoundment underlie consideration of multiple-level withdrawal works. Among the most frequently noted water quality problems that can sometimes be ameliorated by selectively withdrawing water from an impoundment are:

Tastes and Odors--Highly objectionable tastes and odors may be imparted to hypolimnetic waters under anaerobic or low dissolved oxygen conditions, due to decaying organic matter and high sulfide concentrations. In eutrophic reservoirs, water from the euphotic zone may also have some taste and odor from algae, thus restricting the range of depths from which water of suitable quality can be drawn during the stratified period.[45]

Iron and Manganese--Metallic salts of iron and manganese are released from bottom sediments in a reducing environment and may reach concentrations at which objectionable tastes and odors are detectable and staining of clothes occurs. Although primarily aesthetic pollutants, criteria for acceptable maximum levels of iron and manganese are included in federal drinking water standards. Oxidation of excessive iron and manganese during prechlorination of such hypolimnetic water produces undesirable color, which once in a water system, may persist for several weeks.[46] Since buildup of these compounds is normally confined to the deeper, unoxygenated parts of a reservoir, withdrawal from the epilimnion or thermocline may avoid high concentrations of these ions.

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[45] Austin, G. H., D. A. Gray, and D. G. Swain, "Multilevel Outlet Works at Four Existing Reservoirs," Journal of the Hydraulics Division, ASCE, Vol. 95, No. HY6, November 1969, pp. 1793-1808.

Turbidity--Sediment-laden density currents are fairly common in larger reservoirs; their course through a reservoir is influenced by sediment concentrations, inflowing current velocities and temperature differentials.[47] High turbidity may contribute to chlorine demand or interfere with water treatment processes such as coagulation and ion exchange. Using outlets at different depths, water may be withdrawn from above or below the undesirable layer.

Salinity--Because of extensive development of irrigation projects and reuse of water, salinity has become a major problem in the West. Variations of dissolved solids with depth in a reservoir may be pronounced, suggesting that multilevel intakes could be used to select water with acceptable dissolved solids concentrations, if available. These substances are not removed by conventional treatment and may cause tastes at levels higher than the recommended limits.

Radioactivity and Toxic Substances--It has been suggested that knowledge of seasonal stratification, flow patterns, density currents and other characteristics may be useful in special circumstances for protecting quality of water released from a dam or withdrawn for public use.[48] For example, accidental spills of toxic or radioactive substances upstream from a stratified reservoir are likely to be confined to a narrow depth band as the inflow seeks its density level. In the summer stratification period, the pollutant may enter as an overflow or interflow and remain confined to a well defined layer. Use of multilevel withdrawal in this instance could perhaps prevent or minimize interruption of water supply service by safely drawing water from another level. The situation could be complicated, however, by suspended matter absorbing harmful material and settling to the bottom or deeper parts of the reservoir.

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[46] Ibid., p. 1797.

[47] Glymph, L. M., "Summary: Sedimentation of Reservoirs," in Ackermann, W. C., G. F. White and E. B. Worthington, Editors, Man-Made Lakes: Their Problems and Environmental Effects, Geophysical Monograph 17, American Geophysical Union, Washington, D.C., 1973, pp. 342-348.

[48] Love, S. K., "Relationship of Impoundment to Water Quality," Journal of the American Water Works Association, Vol. 53, No. 5, pp. 559-568, May 1961.

Temperature--Although no specific temperature limits exist for municipal water supplies in the United States, there is a definite aesthetic benefit associated with cool waters.[49] If the impounded water supply is used for industrial cooling, economic advantages may also be evident. Because of overriding water quality considerations mentioned previously, it is sometimes not feasible to operate multilevel outlet works solely for maintaining cold water in the supply and distribution system. Withdrawal depth limitations imposed by taste and odor, iron and manganese, or other constituents may necessitate use of water with higher-than-desirable temperature. However, the flexibility of temperature control may be critical in maintaining downstream conditions favorable for other water uses.

Impoundment Releases for Downstream Quality Control. Water quality problems caused by the development of thermal stratification and consequent dissolved oxygen changes should be considered in the planning of any impoundment. Because an impoundment may have a useful operating life of one hundred years or more, probable future stream uses must be analyzed in conjunction with impoundment-induced water quality changes; justification for selective withdrawal or other mitigative project features may not be evident based on current conditions alone. Some uses of selective withdrawal for controlling or influencing downstream water quality are:

Regulation of Temperature--Distinct thermal gradients in a stratified impoundment may permit fairly close control of discharge temperatures. Downstream water uses may in some cases present mutually exclusive temperature requirements, however. It is important that the various needs be identified in the EIS. Use of the stream as a source of cooling water for an electric power generating station or industry would favor release of cold water, as would the creation of a new or maintenance of an existing coldwater fishery. On the other hand, temperatures comparable to those occurring without impoundment might be desirable for irrigation water supplies, recreation and preservation of natural fish life. Since the thermal structure of a stratified impoundment is very much interrelated with water quality, temperature regulation for particular uses cannot be separated from accompanying quality characteristics. Deficiency of dissolved oxygen in water selective discharged from the hypolimnion may negate the benefits of reduced temperatures for downstream fisheries, and the water may also be corrosive or contain concentrations of iron or other substances detrimental to use for public water supply.

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[49] Speece, R. E., "Hypolimnion Aeration," Journal AWWA, Vol. 63, No. 1, p. 6-9, January 1971.

Maintenance of Assimilative Capacity--Release of water containing adequate dissolved oxygen to meet stream standards and waste load requirements may be accomplished by selectively withdrawing from the epilimnion in the summer months. Downstream temperatures are likely to be increased by this mode of operation.

Regulation of Physical and Chemical Quality--Any physical or chemical constituents exhibiting vertical gradients, or affected by inflow density currents, may be controlled to some extent by use of multilevel outlets. Several examples were discussed previously in relation to water supply withdrawals.

Design and Operational Considerations. If selective withdrawal works are proposed as part of an impoundment project plan, the EIS should contain supporting information on their proposed operation relative to water quality or temperature selection. Similarly, predictions of water quality changes, stream uses and hydrographic modifications are necessary to judge whether mitigative measures for water quality control not considered in the EIS warrant attention and study.

An assessment of the need for selective withdrawal facilities should include several considerations. Firstly, determination of existing and future needs and objectives for water quality management should form the basis for design of selective withdrawal facilities. In order to meet specific physical, chemical and biological requirements of the releases, evaluation of the effects of the size, shape, spacing and number of outlets is necessary.[50] Finally, criteria indicating when and how the facilities will be used and formulae for predicting withdrawal layer characteristics are essential for effective operation of multilevel outlet works.[51]

The Tennessee Valley Authority, Bureau of Reclamation and Corps of Engineers have all constructed projects incorporating selective withdrawal facilities, and some hydroelectric dams licensed by the Federal Power Commission also have multilevel outlets. Consequently, knowledge of the hydraulic and water quality behavior of reservoirs under various conditions has been gained both from research and from observations and studies of existing impoundments. Experience has shown that professional judgment or extrapolation of results at one impoundment to another cannot substitute for detailed, site-specific investigations and modelling. Prior to construction of Folsom Dam in California it was concluded, based on experience at the existing Shasta and Friant Dams, that multilevel power outlets would not be required for maintaining suitable fall spawning temperatures for salmon in the American River.[52] The conclusion proved to be incorrect, as cold hypolimnetic water was frequently depleted before the fall spawning period. If multilevel discharge facilities are included in a project plan or if potential water quality problems suggest their inclusion, the reviewer should ascertain that accepted prediction techniques are used (see Section IV.B.2) to provide reasonable assurance that proposed objectives for water quality control will be met.

Use of selective withdrawal may not completely solve the anticipated water quality problems discussed earlier and may have some detrimental effect on water quality. If nutrient loadings in streams draining the area upstream from a proposed reservoir site are relatively high, the situation typified by undesirable algae growth in the epilimnion and oxygen deficiency in the hypolimnion is likely to occur. At the Casitas Reservoir in California nine selective level intakes with a vertical spacing of 7.3 m (24 ft) have not afforded sufficient flexibility to eliminate withdrawal of poor quality water for municipal supply; both treatment with copper sulfate for algae control and destratification by air injection have been used to supplement selective withdrawal.[53]

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[50] Bohan, J. P., and J. L. Grace, Jr., "Selective Withdrawal from Man-Made Lakes," U.S. Army Engineer Waterways Experiment Station, Hydraulics Laboratory, Technical Report H-73-4, Vicksburg, Mississippi, March 1973.

[51] Wunderlich, W. O., and R. A. Elder, "Mechanics of Flow Through Man-Made Lakes," in Ackermann, White and Worthington, ed., op. cit., p. 300-310.

[52] Austin, Gray and Swain, op. cit.

The Corps of Engineers has sponsored a number of studies of the effects of selective withdrawal on water quality and fisheries, the results of which may aid in identifying and assessing potential impacts of different discharge regimes. Analysis of data from more than 100 stratified impoundments indicated that continuous discharges from the hypolimnion may increase dissolved oxygen levels in the deeper parts of a reservoir.[54] The data were reflective of late summer and fall conditions during the period of intense stratification when dissolved oxygen levels would usually be lowest. These results suggest that the fishery potential of a stratified impoundment may be enhanced if releases of relatively poorer quality hypolimnetic water are made.

On the other hand, low-level outlets may deplete the reservoir of nutrients which tend to accumulate in the hypolimnion during stagnation, perhaps contributing to a reduction of productivity in the impoundment and stimulating eutrophication downstream.

The above observations neglect possible downstream thermal requirements and the impact of relatively poorer quality hypolimnetic discharges on waste assimilative capacity and other water uses. Nevertheless, discharges from the hypolimnion or thermocline region may induce water quality patterns in an impoundment that are different from those resulting from release of surface waters. The differences may be important in determining how to operate selective withdrawal works for specific management purposes.

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[53] Ibid., p. 1797-1798.

[54] Stroud, R. H. and R. G. Martin, "Influence of Reservoir Discharge Location on the Water Quality, Biology and Sport Fisheries of Reservoirs and Tail Waters," in Ackermann, White and Worthington, editors, op. cit., pp. 540-548.

Turbine Aeration

Applicable to impoundment projects which provide hydroelectric power generation facilities, turbine aeration offers a means to increase dissolved oxygen concentrations of water drawn through low-level power intakes. The simplest system introduces air through draft tube vents that are built into many projects to control vibration.[55] Air flow is induced by negative static pressures developed in the draft tube. However, the location of modern turbines at or below the tailrace elevation may eliminate negative pressures or produce positive pressures in the draft tubes, necessitating an external power source to force air into the water stream. This difficulty can be overcome by using wedge-shaped deflector plates to create negative pressures and draw air into the draft tube.[56] Once air is introduced, turbulence and increasing pressure enhance absorption of oxygen.

Capital costs for turbine aeration systems are relatively small, and operating costs consist mainly of reduction of generating efficiency. Turbine efficiency losses averaging less than .1 percent to about 5 percent have been reported. Normally, power generating efficiency losses during turbine aeration decrease with increasing head and with increasing flow through the turbine. However, most studies conducted at existing projects have shown that transfer efficiency falls off rapidly as the oxygen concentration in water passing through the turbines increases. Based on present experience with turbine aeration, the technique should not be relied on to increase dissolved oxygen concentrations of anaerobic or poorly aerated water more than about 2-3 mg/l, or less with higher initial oxygen levels. Oxygen transfer may also be less efficient at higher flows than at low flows.

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[55] Wisniewski, T. F., "Improvement of the Quality of Reservoir Discharges through Turbine or Tailrace Aeration," pp. 299-308, in Symposium on Streamflow Regulation for Quality Control, Public Health Service Publication No. 999-WP-30, 1965.

[56] Raney, D. C., and Arnold, T. G., "Dissolved Oxygen Improvement by Hydroelectric Turbine Aspiration," Journal of the Power Division, ASCE, Vol. 99, No. PO1, May 1973, pp. 139-153.

The degree of aeration attainable by simple turbine venting may be insufficient to meet minimum stream standards for dissolved oxygen during summer and fall when oxygen depletion in the hypolimnion is typically greatest.

A highly valued stream fishery might be adversely affected by dissolved oxygen concentrations below 4 mg/l. The concentration of 4 mg/l is a floor value, to protect sizeable populations of resistant species and successful passage of most migrants. Higher concentrations may be needed in many cases, because production of sensitive species may be reduced at the lower DO concentration. Location of a hydroelectric impoundment on a freely flowing tributary stream may present conditions that are conducive to rapid natural reaeration downstream with no significant water uses intervening in the affected reach. In this case, the need for high concentrations of dissolved oxygen immediately downstream from the dam may not be as critical. In assessing any mitigative features for water quality improvement, downstream water uses and water quality requirements should be examined and then compared with expected water quality of impoundment discharges.

Discharge Aeration Using Howell-Bunger Valves

The Tennessee Valley Authority has conducted extensive research regarding the aeration efficiency of the Howell-Bunger valve, a fixed dispersion cone valve. The valve has been used at several TVA impoundments and has been shown to be a very effective aeration device. Aeration efficiencies, defined as the ratio of the difference between the initial and final oxygen deficits to the initial deficit, were found to be consistently greater than 0.8 when outflow velocities exceeded 9 m/sec (30 ft/sec).[57] Initial dissolved oxygen concentrations were not found to appreciably affect aeration efficiency.

It appears that Howell-Bunger valves could be used successfully for aeration at a wide variety of impoundment projects where hypolimnetic discharges are expected to cause downstream water quality problems. The valves may be situated to discharge water horizontally into a containment structure or tunnel as well as directly into the stream channel below a dam. Such facilities could be provided at hydroelectric projects to aerate the relatively small, off-peak discharges occurring at night and on weekends.

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[57] Elder, R. A., M. N. Smith, and W. O. Wunderlich, "Aeration Efficiencies of Howell-Bunger Valves," Journal of the Water Pollution Control Federation, Vol. 41, No. 4, April 1969, pp. 629-639.

Several possible advantages of utilizing Howell-Bunger valves for reservoir discharge aeration should be considered. In contrast to turbine aeration discussed above, a properly designed cone valve aeration system has been found to be very effective in increasing dissolved oxygen to near-saturation values regardless of initial concentrations. The valve could not be used during a peak power generating cycle, however, because of the magnitude of discharges involved. It appears that the Howell-Bunger valve would permit maintenance of both cooler temperatures and better oxygenated conditions downstream from a stratified impoundment in the summer and autumn. Whether the altered thermal regime is beneficial would depend in large part on downstream water supply, cooling, fisheries, recreation, and other uses and needs.

Destratification and Hypolimnetic Aeration

Various systems for mixing and aerating stratified reservoirs have been devised, although actual operating experience has been restricted almost exclusively to impoundments with volumes of less than 5×10^6 m^3 (40,500 acre-ft). The basic purpose of either destratification or hypolimnetic aeration is to eliminate or avoid oxygen depletion and associated water quality changes in the deeper parts of an impoundment. Maintenance of aerobic conditions inhibits leaching of color, solution of iron, manganese and nutrients from bottom sediments, and production of hydrogen sulfide that may be detrimental to various water uses.

Prediction or estimation of the concentrations of objectionable substances that will occur in a new impoundment as a result of anaerobic conditions cannot be done with any degree of certainty using present modelling or quantitative techniques. Nevertheless, it is reasonable to assume that levels exceeding prescribed limits for raw water sources are probable if stable stratification and oxygen depletion are expected. Under these conditions, artificial destratification can be used to maintain dissolved oxygen throughout the reservoir and suppress the solution or leaching of iron, manganese, color and other constituents. However, other possible effects of destratification should also be anticipated, which at some projects may be unacceptable in view of overall water resource needs. Destratification tends to increase the heat budget of an impoundment considerably; the entire water body will become isothermal and exhibit a temperature that may approach that of the epilimnion under stratified conditions. In some instances the cold water reserve of the hypolimnion may be needed for cooling purposes or for regulation of stream temperatures below the dam during certain periods. This situation might arise, for example, during migration and spawning of anadromous species which have very definite thermal requirements. Attempts to lower water temperatures and eliminate oxygen deficits by artificial destratification, thereby creating suitable summer trout habitat, have usually been unsuccessful; desirable dissolved oxygen levels can be maintained but minimum temperatures are increased to intolerable levels.[58]

Table IV-3 and pertinent state water quality criteria should be consulted for thermal requirements applicable to important fish species which may be present in or downstream from a proposed impoundment area. Protection of indigenous aquatic biota or migratory species will in some cases define allowable thermal alterations due to impoundment. Artificial destratification reduces flexibility in downstream temperature control and may lead to unacceptably high temperatures during critical spawning or migration in the autumn. The evaluation of thermal requirements should be coordinated with the U.S. Fish and Wildlife Service or the state fish and game agency if specific constraints due to fisheries exist or if the EIS is deficient or unclear as to possible effects.

Some of the advantages and disadvantages of artificial destratification and hypolimnetic aeration are summarized in Measures for the Restoration and Enhancement of Quality of Freshwater Lakes.[59] Also, several case studies and cost estimates are presented. Although these methods may improve the quality of raw water in an impoundment, reduce treatment costs, and perhaps benefit the reservoir fishery, some detrimental effects have been observed. Basically, not enough is known about the ecological impacts on reservoir productivity, algae, zooplankton and fish to permit a thorough assessment of beneficial and detrimental effects. The need for reservoir aeration or mixing can best be determined after a project becomes operational. Toetz et al. have reviewed and analyzed a large portion of the literature concerning biological impacts of artificial destratification and aeration.[60] This publication should be consulted for additional information on ecological effects.

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[58] Office of Air and Water Programs, Division of Water Quality and Non-point Source Control, and the Office of Research and Development, National Eutrophication Research Program, Measures for the Restoration and Enhancement of Quality of Freshwater Lakes, U.S. EPA, Washington, D.C., 1973 (EPA-430/9-73-005), pp. 86-107.

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[59] Ibid.

[60] Toetz, D., J. Wilhm, and R. Summerfelt, "Biological Effects of Artificial Destratification and Aeration in Lakes and Reservoirs--Analysis and Bibliography," Bureau of Reclamation Report REC-ERC-72-33, Denver, Colorado, October 1972, 117 p.

C. Review of Solid Waste Impacts

Activities during both the construction and operational phases of an impoundment project may generate solid wastes that require handling and disposal. EPA's review should insure that short- and long-term solid waste management requirements have been identified and appropriately quantified in the EIS, and that acceptable disposal methods will be employed to minimize potential adverse impacts.

C.1 Sources of Impacts

Solid waste impacts may occur both in the short term during construction of an impoundment and in the long term, from recreation-generated refuse and other waste sources. Among the common components of solid waste that must be dealt with during the construction phase are: demolition materials (e.g., concrete, brick, wallboard, plaster, and used lumber), packaging materials (e.g., paper, cardboard, plastic, excelsior and metal retaining bands), wood (including trees and scrap lumber); waste concrete, asphalt, garbage, sanitary waste, scrap metal products; rubber, plastic, glass; and pesticides and pesticide containers. During operational phases, flood debris and refuse from public use areas represent the major sources of solid waste. A full review of potential impacts includes the following areas: storage, collection, transport, waste recovery and ultimate disposal of waste materials.

Storage. Storage of solid waste at the construction site is generally temporary; however, provisions must be made for proper handling to minimize impacts. Operations such as clearing and grubbing, stripping of topsoil for future use and excavation can generate a significant amount of "spoil" material. Of particular interest is stockpiled soil which could be transported to nearby streams by erosion processes. Stumps, timber and slash usually present no significant pollution problems, but disposal may pose difficulties because of the massive quantities involved.

Contractors may utilize temporary scrap depots for used or leftover materials such as lumber, various pieces of fabricated metals, large empty containers and other material. Except for empty containers which may have toxic residues, most of this material is nonpolluting.

The impact of refuse generated from food and food containers merits special consideration when the construction activities occur near inhabited areas. The major problem is the potential attraction of rats, dogs and cats to the site. Covered containers strategically placed around the construction site and emptied periodically tend to eliminate these problems.

The long-term impacts of storage considerations are oriented toward reduction of litter, prevention of entry by animals, and reduction of odors. Provisions for temporary storage of recreation-generated refuse obviously must be made. Although open top barrels are often used, enclosed containers with easy to open lids or doors are preferred. A sufficient number of containers should be provided to accommodate peak loads and thus reduce littering. The Corps of Engineers, for example, requires a minimum of one trash receptacle for each two camping sites or one for each three to five picnic tables at its recreation areas.[1]

Collection. The EIS should identify waste collection methods and the frequency of collection (where applicable) both during construction and after the impoundment has been completed. The latter would apply to recreational areas, visitor centers and routine collection of floating debris at outlet structures and log booms. For garbage and other solid waste generated at recreational sites, collection at least twice a week is desirable to minimize problems with flies and odors.

Transport. Transport of solid waste from the construction site to the ultimate disposal area may cause dust and noise problems, and damage to local roads. Narrow roads with gravel shoulders are most susceptible to pavement edge-breaking, especially during periods of alternate freezing and thawing. Covering all loaded materials before travel off-site may be required by state or local regulations. Mud and dust problems from construction vehicles traveling on public ways may be particularly important if the site is near an urbanized area.

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[1] Department of the Army, Office of the Chief of Engineers, "Recreation Planning and Design Criteria," Engineer Manual No. 1110-2-400, 1 September 1971.

Waste Recovery. Waste recovery is important especially where materials are proposed to be disposed of in a local disposal facility. Reduction of waste volume at the construction site will be beneficial and may be necessary if available local landfills would be severely impacted by the added load of construction debris. This reduction in volume would also reduce the vehicle hours travelled on municipal roads. The reuse of "waste" materials, such as production of wood mulch from timber and slash to stabilize slopes and prevent erosion, should be encouraged. This mulch, for example, could be used as a substitute for netting. Also, removal of all marketable timber from areas to be cleared would reduce disposal problems. Since the quantities of spoil material may be significant, its use as fill in borrow areas should also be considered.

The EIS should address the issue of clearing, which may increase the overall impact of solid waste operations. A balance between clearing to facilitate construction operations and preservation of vegetation should be reached, especially if species are unique to the area. Plans should delineate types and extent of various species before construction and show what would be removed and/or replaced after construction.

Ultimate Disposal. Ultimate disposal of construction-generated refuse is the key element in the review of solid waste management operations. For the most part local and state regulations will apply to disposal of such waste. In the absence of either local or state regulations, or if disposal sites are on federal land the "Thermal Processing and Land Disposal of Solid Waste" guidelines should be followed.[2]

Disposal of stumps, timber and slash from clearing and grubbing operations generally represents the largest source of solid waste at an impoundment construction site. Proposed disposal areas and methods should be clearly delineated in the EIS, particularly if a disposal site outside of the impoundment area is required. Unsalvageable demolition debris generated by removing or relocating structures from the flood pool area may in some instances add significantly to waste volumes requiring disposal.

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[2] Federal Register, Volume 39, No. 158, Part III, August 14, 1974.

On-site disposal practices typically consist of some form of land disposal method such as burying the material in an abandoned borrow area or in areas to be subsequently inundated or by open burning. On-site disposal methods should be questioned if disposal of empty chemical containers from paints, solvents, pesticides and herbicides, acids for cleaning masonry, asphalt and other potentially hazardous materials are involved. Many of these containers leave residues which are nonbiodegradable and can remain chemically active for many years. In general the disposal of pesticide containers should be done in accordance with EPA's proposed rules, "Pesticides and Containers; Acceptance, Disposal, and Storage."[3]

A long-term consideration is the disposal of debris which accumulates in and around the impoundment area. This problem may be particularly acute at flood storage reservoirs following pool drawdown. The material brought down by floodwaters consists mostly of fallen timber and brush which remains in the drawdown zone or is conveyed to the dam or trashracks protecting the outlet works. Left to rot, the dried timber may present a serious fire hazard. The EIS for a flood control impoundment should address this problem and indicate how disposal of the debris is to be accomplished, particularly if large quantities are involved.

C.2 Review of Impact Quantification

It is quite difficult, if not impossible, to accurately determine the quantities of construction refuse since site characteristics and the extent of reuse of materials, particularly forming materials, timber, slash and other spoil material vary considerably. However, a general schedule of expected waste generation, including recovered materials, could serve an important function if local community disposal sites are to be used. For example, if peak waste generation periods such as produced from clearing and grubbing and final clean-up operations coincided with peak tourist inflow in a particular community, transporting the solid waste to the local disposal facility might increase traffic congestion or might even result in temporary economic decline from a reduced number of tourists. For on-site disposal this schedule becomes less important.

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[3] *Federal Register*, Volume 38, No. 99, Part II, May 23, 1973, pp. 13622-13626.

Fairly good estimates of waste quantities generated from recreational areas or visitor centers can be made based on projected visitation and the number of various types of facilities. It is important that potential recreational development by private interests as well as the federal government be described in the EIS. Table IV-5 may be used to estimate waste quantities if projections of initial and future recreational development are available.

Table IV-5: Waste Generation Rates for Recreation Sites

Recreation Site	Average rate of waste generation (90 percent confidence interval)
Campground	1.26 ± 0.08 lb/camper day
Family picnicground	0.93 ± 0.16 lb/picnicker
Group picnicground	1.16 ± 0.26 lb/picnicker
Organization camp	1.81 ± 0.39 lb/occupant day
Resort area	
Rented cabin (w/kitchen)	1.46 ± 0.31 lb/occupant day
Lodge room (wo/kitchen)	0.59 ± 0.59 lb/occupant day
Restaurant	0.71 ± 0.40 lb/meal served
Residence	2.13 ± 0.54 lb/occupant day
Observation site	0.05 ± 0.03 lb/incoming axle
Visitor center	0.02 ± 0.008 lb/visitor
Swimming beach	0.04 ± 0.01 lb/swimmer
Concession stand	0.14 lb/patron

Source: Little, H. R., "Design Criteria for Solid Waste Management in Recreational Areas," U.S. Environmental Protection Agency, Solid Waste Management Series Report (SW-91ts), 1972, p. 7.

It is not uncommon for recreational facilities at even fairly small impoundments, with water surface areas of less than 1000 acres or so, to attract several hundred thousand visitors in a season. At larger projects annual visitation may run in the millions. Using a waste generation rate from Table IV-5 of 0.93 lb/picnicker day (0.423 kg/picnicker day) and an annual total of 400,000 picnickers, for example, 186 tons (173 metric tons) of waste would require disposal. Also, most of the refuse would be generated in the 3 or 4 warmer months. This waste load increment would not significantly affect a large sanitary landfill operation. However, a rural landfill serving, say 2000 people, may process 4 or 5 tons per day of refuse, and the addition of an average 1.5 to 2 tons per day during the recreation season may put a substantial burden on the operation and available landfill space.

The quantities of the debris resulting from flood control operations are difficult to estimate. Although no specific techniques exist to assess the magnitude of this debris problem, experience at other impoundment projects in the region may give some insight into the quantities of floating material to expect.

C.3 Assessment of Impacts

The major element in assessing the impact of recreational and other solid waste is the relationship between anticipated waste quantities and the capacity of the selected disposal areas. Initial estimates can be made to determine the significance of solid waste from recreational areas, as described in the preceding section. The development of a landfill especially to serve recreational areas at an impoundment would not in most cases require a significant amount of land, but site characteristics would need to be suitable for avoiding or minimizing potential pollution problems. In general, the guidance on design and operational criteria for recreational landfills contained in "Design Criteria for Solid Waste Management in Recreational Areas,"[4] should be followed. To aid in the assessment a summary of impoundment-related solid waste impacts is given in Table IV-6.

Disposal of construction waste should not pose any pollution hazards if acceptable sites and methods are adequately set forth in construction specifications for the project. Much of the construction debris may normally be buried in

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[4] Little, H. R., "Design Criteria for Solid Waste Management in Recreational Areas," U.S. Environmental Protection Agency, Solid Waste Management Series Report (SW-91ts), 1972.

Table IV-6: Summary of Solid Waste Impacts

Material	Source	Characteristics	Significance	Mitigative Measures
Stumps, timber and slash	Clearing and grubbing	Basically nonpolluting	Economic impact on local community if its disposal site is used. Generally largest source of solid waste. Clearing might result in a potential source source of erosion and sediment transport to streams. If burned on-site, refer to air impact.	Cut and clear selectively; sell marketable timber, reuse on-site as mulch.
Rock	Blasting, excavation of dam foundation, spillway channel, etc.	Basically nonpolluting	If a borrow area is used, might result in permanent scar on landscape unless provisions are made for restoration. Volume may be significant.	Use as rip-rap in core of dams or road foundations.
Masonry waste	Concrete dam or appurtenant structures	Nonpolluting when hardened	Must avoid disposal of wet concrete near bodies of water to prevent siltation.	Use as fill in borrow areas.
Excess building & scrap materials	Forming activities & supplies	Mostly nonpolluting	Litter problem at construction site; partially full containers with toxic materials (solvents, pesticides, acids) might be discarded and cause potential pollution problem due to high localized concentrations. Might be burned at construction site.	Reuse in future projects, estimate material quantities accurately, dispose of empty containers properly, use partially full containers at other jobs.
Food products & containers	Recreational & visitor centers & construction workers	Polluting potential, malodorous	Might create litter and odor problems, and attract animals. Might be burned at construction site.	Provide sufficient number of containers, collect frequently, and dispose of in a landfill or other acceptable manner.
--	Construction vehicles on public roads transporting solid waste to local disposal facility	--	Creates broken pavement, noise, mud on street, dust, and adds to traffic congestion.	Select alternative routes, reduce loads, keep vehicles clean and in good repair. Schedule deliveries to alleviate any potential traffic problems.
--	Excavation of impoundment area	Potentially polluting	Stockpiled soil materials might be a source of sediment to streams.	Place waste material in borrow and fill areas as soon as practicable; grade and seed or apply mulch.
Other spoil material	Debris at log booms, outlet structures; debris from flood waters	Generally nonpolluting	Volume may be significant, especially at flood control reservoirs. Potential killing of trees and other vegetation by submergence; unsightly and harmful mud deposits.	Practice good upstream forestry management; maintain disposal area for this material, adjacent to site (such as borrow area), to reduce impact on local community.

excavation or borrow areas or in the lower reservoir that will be flooded, thus creating few solid waste problems for nearby disposal sites. Where the proposed conservation pool is small and shallow, debris disposal at the bottom of the reservoir may not be feasible or desirable. In this case, an off-site landfill may be required to receive construction waste, particularly stumps and cleared trees and brush. If no discussion of construction waste disposal appears in the EIS and the amount of clearing or other operations suggest the generation of potentially large quantities of solid waste, clarification of these points should be requested.

Estimation and assessment of the effects of open burning of solid waste are discussed in greater detail in the section on air impacts. Generally, open burning should be discouraged unless it has been demonstrated that no feasible disposal alternatives exist. In any case, due caution must be taken to avoid burning smoke-producing materials such as rubber and plastics, or containers with potentially toxic residues. Favorable meteorological conditions should also prevail.

D. Review of Air Impacts

In most cases, the effects of impoundments on air quality will be relatively unimportant in comparison with impacts on water quality and water resources, ecology and land use. Except under special circumstances of proximity to densely populated areas, generation of significant traffic volumes, or probable secondary development, analysis of air quality impacts will probably not be carried out in any detail in an impoundment EIS, nor would it be required. In order that potential air pollution problems are not overlooked, however, guidance is presented for (1) identification of situations where either primary or secondary air impacts may be significant and (2) determination of the adequacy of air quality analysis in the EIS.

D.1 Sources of Impacts

The primary air quality impacts associated with impoundment development occur as a result of construction stage activities. Construction-related air pollution sources are best illustrated by association with the pollutants they produce. These include:

Dust. One of the noticeable types of air pollution at a construction site is particulate matter such as dust and smoke. There are many construction activities which might produce dust including clearing and grubbing, excavation, blasting, drilling, sand blasting and grinding, gunite operations, concrete production, aggregate production and spreading, stockpiling materials, application of lime and fertilizers, pesticides and herbicides, and dust generated by movement of equipment over the construction site.

Combustion By-Products. Another source of particulate matter as well as other air contaminants is open or incinerator burning, where allowed, of wood and other combustible wastes from clearing and grubbing operations. (Such burning should be permitted only when no justifiable alternative is available.) The relatively low burning temperatures associated with open burning usually result in the emission of particulates, carbon monoxide and hydrocarbons; however, the low temperature tends to suppress the emission of oxides of nitrogen. Since the sulfur content of the debris from clearing and grubbing operations is negligible, the resultant emission of sulfur oxides is also negligible. Available emission factors for the burning of wood may be found in "Compilation of Air Pollutant Emission Factors."[1]

Vehicular Emissions. Heavy-duty, diesel-powered vehicles are the primary contributor of construction stage vehicular emissions.

> Diesel vehicles emit pollutants from the same sources as gasoline-powered vehicles: exhaust, crankcase blow-by, and fuel evaporation. Blow-by is practically eliminated in the diesel because only air is in the cylinder during the compression stroke. The low volatility of diesel fuel along with the use of closed injection systems essentially eliminates evaporation losses in diesel systems.
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> Exhaust emissions from diesel engines have the same general characteristics as auto exhausts. Concentrations of some of the pollutants, however, may vary considerably. Emissions of sulfur dioxide are a direct function of the fuel composition. Thus, because of the higher average sulfur content of diesel fuel (0.20 percent S) as compared with gasoline (0.035 percent S), sulfur dioxide emissions are relatively higher from diesel exhausts.
>
> Because diesel engines allow more complete combustion and use less volatile fuels than spark-ignited engines, their hydrocarbon and carbon monoxide emissions are relatively low. Because hydrocarbons in diesel exhaust are largely unburned diesel fuel, their emissions are related to the volume of fuel sprayed into the combustion chamber. New, improved needle valve injectors that reduce the amount of fuel that can be burned can reduce hydrocarbon emissions by as much as 50 percent. Both the high temperatures and the large excesses of oxygen involved in diesel combustion are conducive to high nitrogen oxide emission, however.
>
> Particulates from diesel exhaust are in two major forms--black smoke and white smoke. White smoke is emitted when the fuel droplets are kept cool in an environment abundant in oxygen (cold starts). Black smoke is emitted when the fuel droplets are subjected to high temperatures in an environment lacking in oxygen (road conditions). A hot diesel engine properly adjusted and operated under design loads should emit no visible "smoke."[2]

Emission factors for heavy-duty, diesel-powered vehicles typical of those used at large construction sites are also presented in the publication "Compilation of Air Pollutant Emission Factors."[3]

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[1] U.S. Environmental Protection Agency, Office of Air and Water Programs, Office of Air Quality Planning and Standards, "Compilation of Air Pollutant Emission Factors," Second Edition, AP-42, April 1973, p. 2.4-1.

[2] Ibid., p. 3.1.5-1.

[3] Ibid., p. 3.1.5-2.

Secondary air pollution sources associated with impoundment development include, when applicable, highway development or modification, parking facility development, and recreational area development, such as camping facilities where open fires might be permitted. Induced development of flood plains below an impoundment due to increased flood protection is another possible source of air pollution.

D.2 Review of Impact Quantification

Unless any of the secondary air pollution sources listed are present and apparently significant, only construction stage impacts will warrant evaluation. Even then, unless the reviewer can pinpoint that a major possible impact is evident, no detailed critical evaluation is required.

Should a possible impact be identified, the impact potential should be quantified in terms of the percentage of generated pollutants which would reach the sensitive receptor under the most adverse possible meteorological conditions. The probability of occurrence of worst case meteorological conditions, construction timing and geographical influences must be carefully considered, and background ambient air quality levels must also be established. These inputs combined with an approximation of the magnitude of the project emissions should provide sufficient background for the evaluation of sensitive receptor impact and the need for abatement. For comparative purposes the pertinent National Primary and Secondary Air Quality Standards are listed in Table IV-7. Air quality standards and applicable state implementation plan strategies are specific requirements that must be addressed in any EIS on impoundment projects.

D.3 Assessment of Impacts

The air quality assessment must first identify the primary and secondary air pollution generators associated with the impoundment project. Time span and magnitude of these pollutant generators must also be addressed.

Air pollution-sensitive receptors should be identified. Existing ambient air quality and the air quality influence of area meteorological and geographical conditions should be addressed to the extent applicable.

Table IV-7: National Primary and Secondary Air Quality Standards

Pollutant	Standards
Carbon Monoxide	Primary and Secondary 9 ppm max. 8-hr. conc. 35 ppm max. 1-hr. conc. (not to be exceeded more than once per year)
Oxides of Sulfur	Primary (as SO_2) 0.03 ppm annual arithmetic mean 0.14 ppm max. 24-hr. conc. not to be exceeded more than once per year. Secondary (as SO_2) 0.02 ppm annual arithmetic mean 0.10 ppm max. 24-hr. conc., not to be exceeded more than once per year. 0.50 ppm max. 3-hr. conc., not to be exceeded more than once per year.
Oxides of Nitrogen	Primary and Secondary (as NO_2) 0.05 ppm annual arithmetic mean
Particulate Matter	Primary 75 $\mu g/m^3$ annual geometric mean 260 $\mu g/m^3$ max. 24-hr. conc., not to be exceeded more than once per year.
Photochemical Oxidants	Primary and Secondary 160 $\mu g/m^3$ (0.08 ppm) as a maximum 1-hr. conc., not to be exceeded more than once per year.
Hydrocarbons	160 $\mu g/m^3$ (0.24 ppm) as a maximum 3-hr. conc. (6 to 9 a.m.) not to be exceeded more than once per year.

Source: Title 40, Code of Federal Regulations, Chapter I, Part 50, National Primary and Secondary Air Pollution Standards.

Although in many cases no significant air pollution problems will arise, reasonable care should be taken to see that any possible significant impact is identified, its magnitude estimated and related to existing standards, and that abatement plans (if necessary) are formulated.

For the limited secondary impact of existing highway modification which does not increase capacity, no air quality analysis, either microscale or mesoscale, will be required for rural areas.[4]

In the case of the associated secondary impact of parking facility development, outside of standard metropolitan statistical areas (as defined by the U.S. Office of Management and Budget), no new parking facility or other new indirect source with an associated parking capacity of less than 2000 cars nor any modified parking facility or any modification of an associated parking area which increases parking capacity by less than 1000 cars requires an "indirect source" environmental analysis of air quality impact.[5] EPA's "Interim Guidelines for Review of the Impact of Indirect Sources on Ambient Air Quality," published July 1974, may prove useful for evaluating parking facilities, amusement parks and recreational areas.

Should any question exist as to the significance or impact of any other identified secondary source, the publications referenced may be of assistance.

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[4] U.S. Environmental Protection Agency, "Guidelines for the Review of Environmental Impact Statements: Volume 1, Highway Projects," September 1973.

[5] Title 40, Code of Federal Regulations, Chapter 1, Part 52.22(b).

E. Review of Noise Impacts

In the context of the overall environmental impact of an impoundment project, noise pollution is not ordinarily considered a major impact category. However, depending on the location, size and uses of an impoundment, noise impacts may be significant enough to warrant analysis in the EIS, at least in qualitative terms. The guidelines of this section are intended to assist in identifying probable noise impacts, estimating their significance, and determining the adequacy of noise impact assessment in an impoundment EIS.

E.1 Sources of Impacts

As an environmental pollutant noise may be defined as any sound, independent of loudness, that may produce an undesired physiological or psychological effect in an individual and that may interfere with the social ends of an individual or group. It is important to note that, unlike other forms of pollution, noise has a rapid decay time; that is, when the source is turned off, the noise is dissipated within a matter of seconds, and further degradation of the environment ceases immediately.

Therefore, the impact of noise is primarily dependent upon the characteristics of the sound such as the sound pressure level (loudness), its frequency, pattern and duration, and, of course, the proximity of the receiver, and the existing ambient level of background noise.

The primary and secondary noise generators for an impoundment project will consist of some combination of the following:

- The primary construction noise generated on-site and during on-road hauling operations.
- Facilities constructed as part of the impoundment development (for example, power generating stations).
- Recreational facilities created as part of the impoundment development (i.e. lakes for power boating, trails for motorcycling and snowmobiling, and parking lots adjacent to sensitive facilities).

- Highways and rail lines developed, relocated or expanded as part of the impoundment development.

E.2 Review of Impact Quantification

Probably few EIS's on projects involving impoundments will be encountered which contain detailed analyses of noise impacts. There are several possible reasons: (1) construction noise impacts are of relatively short-term consequence, lasting over a construction period of up to several years, (2) impoundments are often located in remote areas with no sensitive receptors nearby, (3) noise sources associated with impoundment operation and use (power generating facilities, off-road vehicles, motorboats, and others) may be overlooked or dismissed as insignificant. Nevertheless, these noise impacts can be important and should be evaluated in an EIS. Supporting information should be given to justify a conclusion that the impacts are not significant. If special expertise is needed in the area of noise impact analysis, the reviewer should contact the Office of Noise Abatement and Control.

The reviewer should be familiar with the following EPA publications for further background material on the description and evaluation of noise:

a. "Noise Facts Digest," prepared by Informatics, Inc., June 1972.
b. "Fundamentals of Noise Measurement, Rating Schemes and Standards," NTID300.15.
c. "Effects of Noise on People," NTID300.7.
d. "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety," March 1974 (550/9-74-004).

In most cases, the greatest impoundment-associated noise impacts will occur during the construction operations phase. As a first estimate, Tables IV-8 and IV-9 may be used to determine the noise levels generated during various types of construction.

Since the actual noise levels decrease as distance from the site increases, the noise levels established in Tables IV-8 and IV-9 must be adjusted for each

Table IV-8: Typical Ranges of Noise Levels at Construction Sites With a 50 dBA Ambient Typical of Suburban Residential Areas*

	I	II	
Ground Clearing	84	84	Energy Average dBA
Excavation	88	78	Energy Average dBA
Foundations	88	88	Energy Average dBA
Erection	79	78	Energy Average dBA
Finishing	84	84	Energy Average dBA

*Noisiest piece of equipment at 50 feet, other equipment at 200 feet from observer.
I - All pertinent equipment present at site.
II - Minimum required equipment present at site.

Source: Bolt, Beranek and Newman, Inc., "Noise from Construction Equipment and Operations, Building Equipment and Home Appliances, "U.S. Environmental Protection Agency, December 31, 1971, p. 19.

Table IV-9: Typical Ranges of Noise Levels at Construction Sites with a 70 dBA Ambient Typical of Urban Areas*

	I	II	
Ground Clearing	84	84	Energy Average dBA
Excavation	89	79	Energy Average dBA
Foundations	88	88	Energy Average dBA
Erection	79	79	Energy Average dBA
Finishing	84	84	Energy Average dBA

*Noisiest piece of equipment at 50 feet, other equipment at 200 feet from observer.
I - All pertinent equipment present at site.
II - Minimum required equipment present at site.

Source: Bolt, Beranek and Newman, Inc., "Noise from Construction Equipment and Operations, Building Equipment, and Home Appliances," U.S. Environmental Protection Agency, December 31, 1971, p. 20.

receptor under consideration. Table IV-10 may be used to obtain the specific reduction value required.

In addition to the distance reduction, a natural barrier such as a dense growth of trees extending at least 15 feet above any line of sight between the source of noise and extending 100 feet (30.5 m) deep can provide an attenuation of approximately 5 dBA. An additional depth of woods of 100 feet

Table IV-10: Reduction of A-Scale Sound Level at Various Distances from a Vehicular Point Source, Relative to 50-Ft. Distance

Distance (ft)	Distance (m)	Reduction dBA
50	15.3	0
100	30.5	6
150	45.8	9.5
200	61	12
500	153	20
750	230	23.5
1000	305	26
2010	613	33.5
3140	957	40

Source: Anderson, G. S., L. N. Miller, and J. R. Shadley, Fundamentals and Abatement of Highway Traffic Noise, prepared for the Federal Highway Administration, June, 1973, p. 1-32.

(30.5 m) may provide an additional 5 dBA attenuation, but the total attenuation from vegetation should not exceed 10 dBA.

Any receptor noise levels estimated from the preceding tables must be considered in terms of a specified noise level which is either "on or off" as a function of time. If this noise level may be projected over a period of time and the normal background sound level at the receptor is available, the expected receptor noise impact may be converted to impact levels for comparison with those in Table IV-11 through the following operations:

Let L_b = the background noise. This level may be considered as the equivalent sound level (L_{eq}) existing before the introduction of the new noise, provided that its fluctuation with time is small relative to the maximum value of the new noise level.

Let L_{MAX} = the established level of continuous construction noise reaching the receptor.

Let Y = the fraction of the total time for L_b during which L_{MAX} is present.

Let ΔL = $L_{MAX} - L_b$.

Table IV-11 Yearly Average* Equivalent Sound Levels Identified as Requisite to Protect the Public Health and Welfare with an Adequate Margin of Safety

	Measure	Indoor Activity Interference	Indoor Hearing Loss Consideration	To Protect Against Both Effects (b)	Outdoor Activity Interference	Outdoor Hearing Loss Consideration	To Protect Against Both Effects (b)
Residential with Outside Space and Farm Residences	L_{dn}	45		45	55		55
	$L_{eq(24)}$		70			70	
Residential with No Outside Space	L_{dn}	45		45			
	$L_{eq(24)}$		70				
Commercial	$L_{eq(24)}$	(a)	70	70(c)	(a)	70	70(c)
Inside Transportation	$L_{eq(24)}$	(a)	70	(a)			
Industrial	$L_{eq(24)(d)}$	(a)	70	70(c)	(a)	70	70(c)
Hospitals	L_{dn}	45		45	55		55
	$L_{eq(24)}$		70			70	
Educational	$L_{eq(24)}$	45		45	55		55
	$L_{eq(24)(d)}$		70			70	
Recreational Areas	$L_{eq(24)}$	(a)	70	70(c)	(a)	70	70(c)
Farm Land and General Unpopulated Land	$L_{eq(24)}$				(a)	70	70(c)

Code:

a. Since different types of activities appear to be associated with different levels, identification of a maximum level for activity interference may be difficult except in those circumstances where speech communication is a critical activity. (See Figure D-2 for noise levels as a function of distance which allow satisfactory communication.)

b. Based on lowest level.

c. Based only on hearing loss.

d. An $L_{eq(8)}$ of 75 dB may be identified in these situations so long as the exposure over the remaining 16 hours per day is low enough to result in a negligible contribution to the 24-hour average, i.e., no greater than an L_{eq} of 60 dB.

Note: Explanation of identified level for hearing loss: The exposure period which results in hearing loss at the identified level is a period of 40 years.

*Refers to energy rather than arithmetic averages.

Source: U.S. EPA, "Information on Levels of Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety," Washington, D.C., March 1974, p. 29 (EPA 550/9-74-004).

Then the value N, which is the decibel difference between the new L_{eq} and the previously existing noise level (L_b), may be established by reference to Figure IV-3. (This gives a rough "worst case" estimate.)

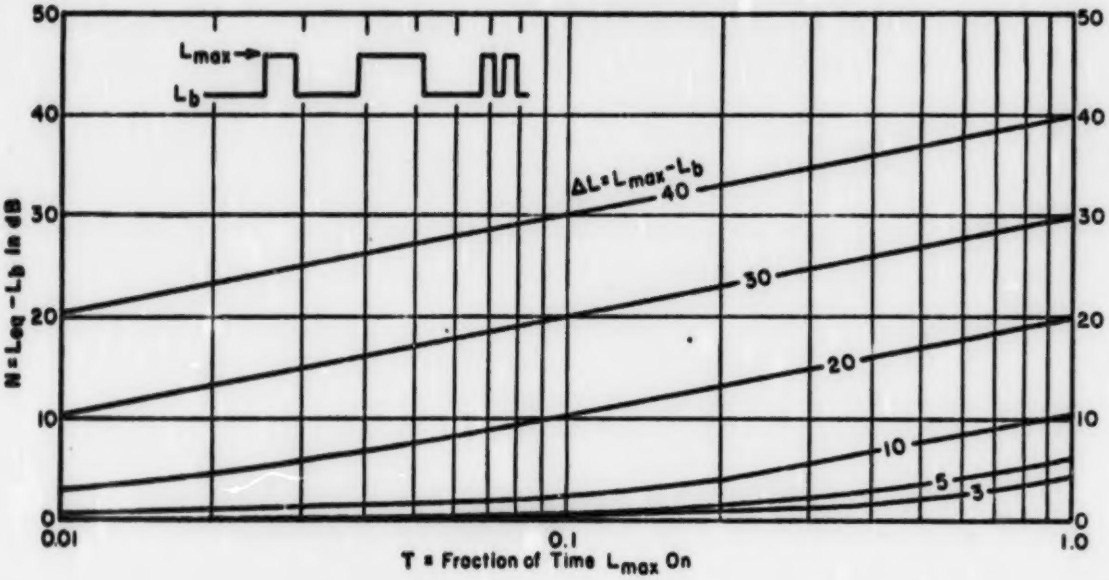

Figure IV-3: L_{eq} for Intermittent L_{max} to L_b

Source: U.S. EPA, Office of Noise Abatement and Control, "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety," Washington, D.C., March 1974, p. A-8.

It is most important that the significance of the predicted L_{eq} noise impacts be weighted by the total time span (the length of the construction stage) over which they will be experienced as well as by the sensitivity of the receptor at the time of day during which impacts will actually occur.

E.3 Assessment of Impacts

Although noise can be a subjective experience in that the same sound might be objectionable to one observer but not to another, the following direct and indirect effects on humans have been well documented.

Hearing Damage Risk. Potential hearing impairment, which is a direct effect of noise, is of prime importance. Hearing impairment may be classified as temporary or permanent. Temporary hearing impairment may result from exposure to high impulse noise such as from blasting or impact equipment; however, repeated exposure to such noise or continuous high level noise (above 90 dBA) can produce permanent hearing damage. Except under unusual conditions, hearing damage risk to persons off the impoundment construction site is almost nonexistent.

Communication. Another direct effect of noise is its potential interference with normal speech conversation and teaching, telephone communication, listening to television and radio broadcasts, and listening to music.

Relaxation and Sleep Interference. Noise affects sleeping habits in two ways: first, it may lengthen the time taken to fall asleep and second, it may interrupt sleep stages and may ultimately lead to awakening.

Other Effects. Physiological and psychological stress, annoyance and task interference are for the most part dependent on the particular individual and it is therefore difficult to establish criteria. Physiological stress may include increase in blood pressure and heart beat rate, such as from a sudden, high level sound (blasting). Noise may also be a contributing factor to headaches, indigestion, ulcers, "heartburn" and gastro-intestinal complications. Noise generated from impact equipment such as from pile drivers, jack hammers and rock drills is a likely source for most physiological stress. This equipment might also be responsible for so-called psychological effects, including increased irritability and nervous tensions. The type of noise is particularly important in determining the effect on individuals in this category of effects. High frequency sounds also tend to be more disturbing than low frequency at the same level.

The masking effect of noise may also present a serious hazard if auditory caution signals are masked (railroad crossing, back-up alarms on construction vehicles).

The effects of noise on wildlife are varied and the reviewer should consult "Effects of Noise on Wildlife and Other Animals."[1] This may be particularly important if endangered species are involved.

Further information on the determination of the effects of noise may be obtained from "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety."[2] This document presents informational noise levels based on current analyses, extrapolations and evaluations of the present state of scientific knowledge. The informational levels provided in this report are listed in Table IV-10. These noise level values are given in L_{eq} (24) and L_{dn}. L_{eq} (24) is an equivalent A-weighted sound level over 24 hours. L_{dn} is an L_{eq} (24) sound level with a 10 decibel penalty applied to nighttime levels. The levels provided should not be construed as standards, nor should they be thought of as discrete numbers, since they are described as energy equivalents representing noise levels based upon cumulative exposure over a period of time. It must be kept in mind that the data upon which the information statistics in Table IV-11 are based is not "short run" or single event noises.

In summary, each of the following areas must be assessed to a degree sufficient to fully explore all short- and long-term probable noise impacts associated with the project under review.

- Sufficiency of background and technical information in the introduction to the topic of noise.
- Adequacy of identification of existing noise levels, probable sources of impacts and probable impacts, both direct and indirect.
- A discussion of applicable noise control regulations including
  (1) Existing noise ordinances
  (2) Construction contract specifications concerning noise
  (3) Responsibility for contract specification enforcement

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[1] Memphis State University, "Effects of Noise on Wildlife and Other Animals," prepared for U.S. Environmental Protection Agency, Office of Noise Abatement and Control, Washington, D.C., 1971, 74 p.

[2] U.S. Environmental Protection Agency, Office of Noise Abatement and Control, "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety," March 1974 (550/9-74-004).

- Possible noise abatement strategies, if necessary. See "Noise Source Abatement Technology and Cost Analysis Including Retrofitting."

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[3] U.S. EPA, Office of Noise Abatement and Control," Noise Source Abatement Technology and Cost Analysis Including Retrofitting," July 27, 1973 (NTID 73.5).

APPENDIX

FEDERAL AGENCY PROCEDURES RELATED TO ENVIRONMENTAL ASSESSMENT OF IMPOUNDMENT PROJECTS

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U.S. Army Corps of Engineers[1,2,3]

The U.S. Army Corps of Engineers acts as an engineer consultant to Congress and develops most of its water resources projects by specific Congressional authorization. When local interests feel the need for a flood control project, they petition their representatives in Congress. The Senator or Representative then requests the appropriate Congressional committee to direct the Corps to make a survey and furnish necessary recommendations. The authority for a study is either a resolution adopted by appropriate Senate or House Committees or a Congressional Act. Some studies may be confined to a small area and have a comparatively simple solution. Other studies may cover an entire river basin and require consideration of navigation, flood control, erosion control, hurricane protection, water supply, water quality control, hydroelectric power, drainage, irrigation, recreation, and others.

When Congress makes funds available for construction, the Corps prepares plans and specifications, awards contracts, and supervises construction. The completed projects may be operated and maintained by the Corps, or they may be transferred to another agency or to local interests to operate and maintain. For projects with limited scope, Congress has authorized the Secretary of the Army and the Chief of Engineers to approve these projects. Projects of limited scope include small river and harbor improvements for navigation, small flood control projects, shore and beach restoration, emergency bank protection, channelization, flood repair, removal of wrecked vessels, and dissemination of information to states and local communities. Generally, for projects in which federal financing is more than $1,000,000, Congressional approval for investigation and installation is required; whereas, projects in which federal financing is less than $1,000,000 receive Corps approval.

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[1] Administrative Procedures, Environmental Impact Statements, 33 CFR Part 209.

[2] Office of the Chief of Engineers, Department of the Army, "Engineering Manual: Survey Investigations and Reports, General Procedures," revised through August 29, 1969.

[3] Office of the Chief of Engineers, Department of the Army, "Preparation and Coordination of Environmental Statements," April 15, 1974.

The projects receiving congressional approval are different in nature and scope from projects receiving Corps approval. As such, the Corps has elected to employ two separate planning processes.

A. Congressionally Approved Projects

The planning process for congressionally approved projects consists of the following six steps:

(1) Project Investigation. During this step an inventory of environmental resources is made, and the District Engineer (DE) prepares a summary of environmental considerations. A determination is made on whether further investigation and expenditure of funds for a more comprehensive and detailed survey are warranted. Public participation in the form of public meetings is initiated and is used to develop a dialogue to assist in the formulation of the project and the identification of environmental concerns. Also at this time, coordination with federal, state and local agencies is begun. Where necessary, assistance from these agencies may be requested.

(2) Public Hearings. This activity provides a means for the DE to make recommendations for improvements. Through a series of public meetings, in which alternatives for improvements are discussed, the DE is able to refine his determination of the proper scale and scope of improvements, the economic justification, and the equitable sharing of costs and responsibilities by federal and nonfederal interests. These findings make up the Survey Report which is completed at this time. Also completed at this time is the Preliminary Draft EIS. The DE circulates the Survey Report and the Preliminary Draft EIS to concerned federal, state, and local agencies, and citizen groups, and individuals on the project mailing list for review and comment. Utilizing the comments received, the DE revises the above reports, which then serve as a basis for the DE to make recommendations for improvement.

(3) Corps Recommendations. The Survey Report and the Draft EIS are reviewed by the Division Engineer, the Office of the Chief of Engineers (OCE), and the Board of Engineers for Rivers and Harbors (BERH). Based upon this review, OCE and BERH make proposed recommendations.

(4) Formal Review and Comment. OCE completes the Draft EIS. The Survey Report and the Draft EIS are then circulated for review and comment to local, state, and federal agencies at the Washington level in accordance with established procedures. The Draft EIS and other reports are furnished to the Council on Environmental Quality (CEQ) at this time.

Based on the comments received, BERH may revise its recommendations, the DE prepares the Final EIS, and OCE prepares its final report on the proposed project.

(5) Transmittal of EIS. The Final Report and the Final EIS are transmitted by OCE to the Office of the Secretary of the Army (OSA) for review. Following the review, OSA transmits these documents to the Office of Management and Budget (OMB). OMB reviews the documents and furnishes OSA with comments, which are then incorporated into the Final Report. OSA then transmits the report to Congress with its recommendations for improvements. A copy of this report is sent to CEQ, EPA, the DE, the Division Engineer, state and local agencies, citizen groups, and individuals on the project mailing list. OCE also informs the public that the Final EIS is available for review.

(6) Approval. The Senate and House Committee on Public Works holds open hearings on the Final Report submitted to Congress for the purposes of deciding whether to include the project in an "omnibus" River and Harbor and Flood Control Bill. If included, the passage of the act will authorize the construction of the project.

After the hearings, the Committee concerned prepares a report on the bill under consideration. The proposed bill is brought to the floor of Congress for consideration. Enactments by Congress and approval by the President authorize construction of the project. Authorization does not provide funds for construction and planning. Therefore, funds must be secured independently through the normal procedures of budget presentation and annual appropriation proceedings.

B. Corps Approved Projects

The planning process for Corps-approved projects consists of the following four steps:

(1) Project Investigation and Findings. The DE undertakes a reconnaissance study to determine if a detailed study is warranted. If detailed studies are warranted, the DE undertakes studies to determine the scope and nature of the project. At the same time, public meetings are held to assist the DE in project formulation as well as identification of environmental concerns. The DE concludes the detailed studies by preparing a Detailed Project Report (DPR) and a Draft Environmental Impact Statement (DS).

(2) Review and Comment. The DE circulates the DS and the DPR to concerned federal, state, and local agencies for review and comment. At the same time, the DE will circulate the DS for review and comment to other agencies, groups, and individuals on the project mailing list. In addition, copies of the DS will be furnished directly to CEQ and higher authorities. CEQ issues a news release informing the public of the availability of the DS.

After receipt and evaluation of agency review comments, comments of the interested public, and information obtained at the public meeting (optional), the DE prepares the Final Environmental Statement (FS) and completes the Detailed Project Draft.

The Division Engineer then approves the project formulation and technical aspects of the project report and the adequacy of the FS and transmits these documents to OCE.

(3) Transmittal. After OCE reviews the DPR and the FS for policy and procedure, OCE or OSA will transmit the FS to CEQ. In addition, the DE will furnish copies of the FS to agencies, groups, and individuals on the project mailing list, as well as provide copies to the appropriate states and regional and metropolitan clearinghouses. Furthermore, CEQ will issue a news release informing the public of the availability of the FS.

(4) Approval. At the appropriate time, OCE approves the DPR and authorizes the project. OCE notifies the Division Engineer who then notifies the governor and interested congressmen of the project approval.

Soil Conservation Service[4,5,6,7]

The Watershed Protection and Flood Prevention Act of 1954 (PL 566) as amended provides for technical, financial, and credit assistance for watershed planning and program development for the conservation of soil and water resources. Local organizations are responsible for the initiation and development of projects. Close cooperation and assistance of local, state, and federal agencies are generally encouraged.

To be eligible for federal assistance, a watershed project must not exceed 101,000 hectares (250,000 acres) in size nor can it include any single structure which provides more than 1.54×10^6 m^3 (12,500 acre-feet) of floodwater detention capacity nor more than 3.08×10^6 m^3 (25,000 acre-feet) of total capacity. The planning process for watershed projects is initiated when a sponsor applies for planning assistance to deal with authorized project purposes. Authorized purposes which may involve impoundments include watershed protection, flood prevention, agricultural water management, public recreation, public fish and wildlife, municipal and industrial water supply and water quality management. The sponsor may be a state or political subdivision thereof, soil or water conservation district, flood control district or any other agency having authority to carry out, operate and maintain works of improvement. Nonprofit irrigation or reservoir companies, water users' associations or similar organizations having such authority are also eligible if approved by the Secretary of Agriculture.

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[4] Compliance with NEPA, 7 CFR Part 650.

[5] United States Department of Agriculture, "USDA Procedures for Planning Water and Related Land Resources," March 1974.

[6] Soil Conservation Service, United States Department of Agriculture, Watershed Protection Handbook: Part 1 - Planning and Operations" August 1967 (updated through May 1, 1974).

[7] Soil Conservation Service, United States Department of Agriculture, "Environmental Impact Statements: Guidelines for Preparation" Federal Register, Volume 39, Number 107, June 3, 1974.

Despite the differences in authorization, all watershed projects employ a similar planning process for the development and review of the EIS. This planning process is described in the following six step procedure:

(1) Application Development. Application for planning assistance is initiated and completed by local organizations such as water conservation districts, etc. Public meetings to define and evaluate watershed problems are conducted in concert with the application development. Comments from state and areawide A-95 clearinghouses are received and included in the application. The application is prepared by the sponsoring organization and submitted to a designated state agency for approval. If an application is disapproved, no further action is taken by the SCS. The designated state agency may defer action until a field examination, under the direction of the SCS, is conducted to acquire sufficient information. If the application is approved, the state conservationist, after a thorough review, transmits it to the SCS Administrator. The Administrator acknowledges receipt of the application by notifying the sponsors, state conservationist, and appropriate clearinghouses.

(2) Preliminary Investigation. Once a request for planning assistance has been approved, the state conservationist, with the assistance of the SCS and participating agencies, conducts a preliminary investigation of the project. Sufficient information is assembled to determine if national and regional standards are met. Public meetings are held to obtain and disseminate information, discuss alternatives, and reach a tentative consensus on the impacts of available alternatives. Based on preliminary investigation, the state conservationist may request authorization to begin planning and preparation of the EIS.

(3) Detailed Planning. Once the Administrator grants planning authority, appropriate agencies, organizations, and heads of government are notified. Those notified include the designated state agency, state conservationist, heads of concerned federal agencies, the sponsoring local organizations, and appropriate clearinghouses.

With the initiation of planning, a preliminary draft EIS is prepared by the sponsors under the direction of the state conservationist. Agencies assisting are determined by the state conservationist and CEQ guidelines. The guidelines for watershed or channelization projects do not include the EPA as an agency having jurisdiction or legality to assist. The preliminary draft EIS is then reviewed and commented on by the public, appropriate clearinghouses, and other interested local, state and federal agencies. Following the informal field review, the state conservationist prepares the draft EIS which is reviewed by the Technical Service Center.

(4) Formal Review and Comment. The state conservationist distributes the draft EIS for a formal interagency review. Those included in the review are CEQ, sponsors, heads of governments, designated state agencies, appropriate state and federal agencies, clearinghouses, and the general public. Review and comment are requested within 60 days. Comments received are used by the state conservationist in the preparation of the final EIS, which is then reviewed by the Technical Service Center.

(5) Transmittal of EIS. The state conservationist signs and approves the final EIS. If the project required congressional approval, the Administrator also signs and approves the final EIS. Following the correct procedure for approval, the final EIS is transmitted to the CEQ, Secretary of Agriculture, all commenting agencies, and the public. In addition, statements involving projects requiring congressional approval, will be transmitted to the appropriate congressional committees.

(6) Authorization. Final approval to proceed with the project is given. For congressionally approved projects, appropriate congressional committees approve the project, with the Administrator authorizing installation. For administratively approved projects, the state conservationist approves the project and authorizes installation. In both cases, the Administrator notifies the designated state agency, heads of governments, sponsors, appropriate state and federal agencies, and general public that federal assistance in the installation of works of improvements is authorized.

Bureau of Reclamation[8,9]

The Reclamation Act of 1902 (43 U.S.C. 391 et seq.) authorized the Secretary of the Interior to locate, construct, operate, and maintain works for the storage, diversion, and development of waters for the reclamation of arid and semi-arid lands in the western states. A Reclamation Service was established in the Geological Survey, was later separated from the Survey, and was renamed the Bureau of Reclamation in 1923. In promoting optimum development of water and related land resources in the seventeen contiguous western states, the Bureau's program has expanded to include impoundments that may serve some or all of the following concurrent purposes: irrigation water service, municipal and industrial water supply, hydroelectric power generation, flood control, navigation, and related uses.

The development of a reclamation project may be initiated by the Bureau itself or at the request of a local agency or group. In the latter case, the local sponsors must bear one-half of the cost of the investigation. The study process entails two major steps: (1) a preliminary reconnaissance investigation, generally defined as recognition of potential development, collecting all readily available information in the particular area, and having as its chief purpose the determination of whether further investigation is justified, and (2) a feasibility investigation, based on the reconnaissance report, which is conducted to determine the engineering, economic, and financial feasibility of a project.

When a project is proposed, the Commissioner of Reclamation, upon receiving clearance from the Office of the Secretary of the Interior, directs the appropriate Regional Office of the Bureau to undertake a reconnaissance investigation. This first phase study is normally funded from annual appropriations for investigation. The Area Development Office in the vicinity of the proposed project conducts the field investigations. The Regional Director

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[8] Reclamation Instruction Series 350, Part 376, "Environmental Quality--Preservation and Enhancement," Bureau of Reclamation.

[9] Ely, N., "Authorization of Federal Water Projects," National Water Commission, Arlington, Virginia, November 1971, (NTIS PB-206 096).

then uses this information to prepare a reconnaissance report which is coordinated with interested agencies and groups.

If the reconnaissance report indicates that further study of a project is justified, the Bureau seeks authorization and funding for a feasibility investigation. Again, the Area Development Office where the project is located carries out the feasibility investigation and prepares a draft report that describes the findings and serves as the basis for receiving construction authorization. The feasibility components must each be thoroughly analyzed. Engineering feasibility relates to the adequacy of site conditions, hydrology and other physical factors influencing design, construction or operation of the project. The economic feasibility criterion specifies that project benefits must exceed costs, including evaluation of both primary and secondary gains and losses as well as a description of intangible values affected by the proposed project. The study of financial feasibility concentrates on the equitable distribution of costs among various project purposes and whether reimbursable costs can be returned by project beneficiaries.

Several federal agencies, including EPA, may assist the Bureau in these feasibility evaluations. The Bureau itself generally assesses irrigation benefits derived from a proposed project. Hydroelectric power benefits are evaluated with the assistance of the Federal Power Commission. The Corps of Engineers supplies information concerning flood control and navigation, both of which are generally nonreimbursable project benefits. EPA may be called on to furnish data concerning water supply and treatment, water quality benefits associated with the proposed project, or the value of storage allocated specifically to flow augmentation for quality control. The Fish and Wildlife Service and the Bureau of Outdoor Recreation may be consulted for evaluation of project benefits and costs in their respective areas of expertise.

After completion of the feasibility studies, the Area Development Office in charge of the investigation prepares a draft of a proposed planning report and a draft environmental statement, and forwards them to the Bureau's Regional Office for review. The drafts are then circulated for review and comment to interested local and state agencies and to regional offices of interested federal agencies. After further review by national levels of the Bureau, a final draft of the report is prepared and submitted to the Secretary of the Interior for approval and adoption. Comments on the final draft are solicited from affected or interested state and federal agencies, and the Secretary's final feasibility report is transmitted to the Office of Management and Budget, the President and Congress for authorization and funding.

Because of federal emphasis on comprehensive planning for water and related land resources, the Bureau's program has begun to shift from isolated, project-oriented reconnaissance investigations and reports to more broadly based planning activities. This planning falls generally into three areas: (1) Comprehensive framework (Type I) studies begun under the Water Resources Planning Act of 1965; (2) a Western United States Water plan which provides reconnaissance coverage of eleven of the seventeen states in the Bureau's jurisdiction; and (3) reconnaissance type state-wide plans for Kansas, Colorado, Montana, Nebraska, Oklahoma, and New Mexico which are not included in (2) above. With the exception of some projects for which reconnaissance studies have been completed, new impoundments will generally be studied as part of one of the above planning processes being used by the Bureau with the feasibility phase for individual projects based on information in the more comprehensive reconnaissance study.

Tennessee Valley Authority[10]

The Tennessee Valley Authority, a corporation wholly owned by the federal government, was created by an act of Congress on 18 May 1933. Its basic purpose is to conduct a unified program of conservation, development, and use of the resources of the Tennessee Valley. The TVA presently operates a system of dams and reservoirs on the Tennessee River and tributaries and investigates the need for and feasibility of additional river control projects in the region. Impoundment purposes are varied and may include development of navigation, flood control, hydroelectric power, water supply, recreation, irrigation and other beneficial uses of water.

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[10] Tennessee Valley Authority, "Environmental Quality Management: Policy and Procedures," Federal Register, Vol. 39, No. 2, February 14, 1974.

Consideration of the environmental aspects of a proposed TVA action is to begin at the earliest possible point in the planning process. TVA's policy and procedures relating to implementation of NEPA and EIS's require the preparation of an Environmental Evaluation Record (EER) when project planning is initiated. The EER contains three major sections:

(1) Description of the need or opportunity which has arisen and which is expected to lead to a proposal for an action, including preliminary identification of alternatives.
(2) Proposal and discussion of one or more solutions that are to be favored in the planning process.
(3) Outline of environmental compliance procedure.

These steps are fully coordinated internally within TVA to uncover alternatives and special environmental problems and otherwise assist the initiating office, which in the case of impoundments is normally the Division of Water Control Planning. The Division of Environmental Planning works closely with the initiating office throughout the planning and EIS development stages of a proposed project.

The outline of environmental compliance procedures lists both the important steps in the planning process and the studies and investigations required to assess a proposed action. The initiating office also recommends an appropriate time in the planning process for issuing a draft EIS based on a schedule for studies and gathering pertinent environmental information. EPA and other federal or state agencies may be requested to investigate specific aspects of the proposed project during the planning phase. Consultation and coordination with non-TVA groups may also take place through normal working relationships that have been established.

Relevant information from the EER and from other studies is synthesized into a preliminary draft EIS after consultation with the Division of Environmental Planning regarding the need for additional investigations to complete the environmental assessment. This preliminary draft is reviewed by offices and divisions within TVA, revised as necessary, and transmitted to the General Manager, who may approve or reject the document. If rejected, the draft is returned with instructions for revisions. When the General Manager approves the preliminary draft, it becomes the draft environmental impact statement and is submitted to CEQ and to interested agencies and groups for external review, subject to CEQ guidelines and procedures established pursuant to the Office of Management and Budget Circular A-95.

Special environmental studies conducted within TVA and by other agencies during planning for a proposed impoundment project will normally be summarized and referenced in the draft EIS. The reviewer should thus be able to contact the agency responsible for investigating a certain environmental aspect of a project, or obtain the original report, if he has questions on information included in the EIS.

Federal Power Commission[11]

The use of hydroelectric power is regulated at the federal level by the Federal Power Commission (FPC). The FPC is an independent agency of the federal government originally established in 1920 under the Federal Water Power Act, which extended federal control over water power development on navigable streams. The Commission's authority covers the licensing and regulation of both conventional and pumped-storage hydroelectric projects.

An applicant for an FPC license may be a utility company, a private business or association, an individual, a municipality, or a state. FPC's guidelines concerning implementation of the National Environmental Policy Act of 1969 (NEPA) require that all applications for major projects (those in excess of 2,000 horsepower) or for reservoirs only providing regulatory flows to downstream (major) hydroelectric projects shall be accompanied by Exhibit W, the applicant's detailed statement on environmental considerations. The same requirement applies also to applications for amendment of a license proposing changes in construction or operation of a project. This report is one of several exhibits which the applicant must prepare and submit to the FPC along with the license application. If, after initial review of the materials submitted, it is determined that the proposal will be a major federal action significantly affecting the quality of the human environment, the Commission staff will proceed to prepare an environmental impact statement. Often the applicant's Exhibit W is used directly as the EIS.

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[11] Federal Register, Vol. 38, No. 117 (June 19, 1973), p. 15946.

Other exhibits of particular interest to the EIS reviewer are Exhibit H--operation of the project with respect to water use and quality, Exhibit R--recreation plan, and Exhibit S--impact on fish and wildlife. Applicants are expected to have consulted with appropriate federal, regional, state and local entities during the preliminary planning stages for the purpose of identifying relevant environmental factors. As these exhibits may contain a considerable amount of background information which is not always put into the EIS, the reviewer should make sure he has copies of them to assist in the impact evaluation.

The question of low-flow augmentation at FPC projects is specifically addressed in Section 102 of the Federal Water Pollution Control Act Amendments of 1972. The law states that:

> No license granted by the Federal Power Commission for a hydroelectric power project shall include storage for regulation of streamflow for the purpose of water quality control unless the Administrator [of EPA] shall recommend its inclusion...

Evaluation of a water quality storage proposal should be conducted in accordance with EPA's policy on low-flow augmentation. Although the reviewer of a project EIS would not normally be responsible for this evaluation, he should nevertheless be acquainted with any water quality concerns raised in those cases where flow regulation for water quality control has been studied by EPA.

Water Resources Council and River Basin Commissions--Water Resources Planning Act[12]

The Water Resources Planning Act of 1965 has as its stated purpose:

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[12] Principles and Standards for Planning Water and Related Land Resources, Federal Register, Vol. 38, No. 174, September 10, 1973, p. 24778-24869.

> to provide for the optimum development of the Nation's natural resources through the coordinated planning of water and related land resources, through the establishment of a water resources council and river basin commissions, and by providing financial assistance to the states in order to increase state participation in such planning.

The Water Resources Council is composed of the Secretaries of Interior, Agriculture, Army, Health, Education and Welfare, Transportation, and the Chairman of the Federal Power Commission.

The Council has primary responsibility for continuing studies and periodic assessments of the adequacy of water supplies in the United States. The Council also reviews water and related land resource plans prepared by river basin commissions, or by interagency coordinating committees, and formulates recommendations on these plans prior to transmittal to the President and Congress.

The Water Resources Planning Act directed the Council to establish guidelines for water resource planning as well. The "Principles and Standards for Planning Water and Related Land Resources" provide guidance for developing comprehensive plans through the coordinated efforts of federal, state and local governments, private businesses and organizations, and individuals. The standards apply to the impoundment planning and evaluation studies normally carried out by federal agencies, as well as to river basin commissions, federal-state interagency or coordinating committees, and other entities engaged in comprehensive water resource planning with coordinated federal technical or financial assistance.

River basin commissions created under the 1965 Act serve to coordinate federal, state, interstate, local and nongovernmental water and related land resources development plans in their areas. The commissions may undertake and encourage studies of problems that relate to the preparation or updating of a comprehensive, coordinated plan for water resource development, and may make recommendations concerning individual water projects included in a comprehensive plan.

The Water Resources Council defines three levels of planning: Level A, framework studies and assessments, Level B, regional or river basin plans, and Level C, implementation studies. The framework studies are comprehensive evaluations of regions with complex water resource problems that require interagency and interdisciplinary coordination. The framework study may lead directly to recommendations for undertaking implementation studies without further study or to "Level B" planning at the river basin, sub-basin or regional level.

This second level of planning addresses the complex, long-range problems identified in the framework studies through reconnaissance-type studies. One federal agency, such as a river basin commission, the Bureau of Reclamation, or the Corps of Engineers, may take the lead for coordinating interagency involvement in development of a regional or river basin plan. Section 209(a) of the Federal Water Pollution Control Act Amendments of 1972 provides that Level B plans be completed by the Water Resources Council for all river basins in the United States by 1980.

Implementation studies are program or project feasibility studies, usually undertaken by a single federal, state or local agency. Their purpose is to carry out the recommendations contained in higher level plans, and in the case of federal impoundments, the planning process would be comparable to that used by the various agencies involved. Such plans are oriented to near-term needs which have been identified and require action within 10 or 15 years.

The reviewer of an impoundment EIS is specifically concerned with this third implementation study phase of a proposed project. However, more comprehensive Level A or B or similar studies, if they have preceded planning for an individual project, may contain considerably more information on regional characteristics, interrelationships with other existing or planned water resource developments, alternatives, and other factors than is found in the EIS. The Water Resources Council planning standards call for full evaluation of "without project" and "with project" conditions and an accounting of beneficial and adverse effects in four categories: national economic development, environmental quality, regional development and social well-being. The standards also discuss quantification of these effects, in monetary terms or otherwise. Since the EIS for an impoundment is apt to be the product of numerous earlier planning and environmental studies, the reviewer should refer, if necessary, to these documents for background information and data on the project. Planning studies done under the auspices of the Water Resources Council may be particularly useful for tracing the development of a project and understanding its basin-wide implications.

Fish and Wildlife Service--Fish and Wildlife Coordination Act

The major activities of the United States Fish and Wildlife Service occur under the authorization of the Fish and Wildlife Coordination Act of 1934, as amended. The Bureau of Sport Fisheries and Wildlife was established in the Department of the Interior by the Fish and Wildlife Act of 1956, as amended; this Bureau is directly involved with environmental coordination of federal water resource development efforts. Enabling legislation provides that fish and wildlife conservation, protection and enhancement receive equal consideration along with other water resources project purposes and that any federal agency or licensee proposing to modify or control any stream or water body must first consult with the Fish and Wildlife Service and with the fish and wildlife agencies in the state(s) in which a project is to be located.

The Division of River Basin Studies in one of the six regional offices of the Bureau of Sport Fisheries and Wildlife is responsible for carrying out the duties of the Fish and Wildlife Service under the Fish and Wildlife Coordination Act. The Bureau staff normally conduct surveys and investigations concurrently with ongoing planning, feasibility, or other studies by the lead agency. Their report contains an inventory of fish and wildlife species and habitat types in the proposed project area, including any rare, endangered or other unique biota, probable beneficial and adverse effects of the project on these resources, means to mitigate damages, and ways to develop and improve fish and wildlife values. The report and recommendations of concerned state fish and wildlife agencies accompany any report submitted by the originating agency to Congress. The views expressed in the report are also usually integrated into the draft environmental statement for a proposed project.

The Bureau of Sport Fisheries and Wildlife generally becomes involved early in the planning process in the case of Corps of Engineers and Bureau of Reclamation projects, as well as in the EIS review phase.

The Fish and Wildlife Service may or may not conduct studies of proposed small watershed projects of the Soil Conservation Service. However, state fish and wildlife agencies will normally investigate such proposed projects whether or not the Service participates directly.

For hydroelectric projects under the jurisdiction of the Federal Power Commission, Exhibit S, a report on fish and wildlife resources, must be submitted with applications for licensing or relicensing. The exhibit should describe the effects of the project on fish and wildlife resources in the project area or in other areas affected by the project and potential mitigation or enhancement measures. The applicant for a license prepares the report "on the basis of studies made after consultation and in cooperation with the U.S. Fish and Wildlife Service, Department of the Interior, and appropriate state fish and wildlife agencies..." The Fish and Wildlife Service reviews Exhibit S and Exhibit W, the applicant's draft environmental statement, and recommends license stipulations and other requirements relating to conservation and development of fish and wildlife resources affected by the project.

The reviewer should regard the Fish and Wildlife Service as a source of technical assistance in all areas of fish and wildlife conservation and management, particularly with respect to ecological impacts of flow regime, thermal, water quality and habitat changes resulting from impoundment.